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THE FRANKLIN INSTITUTE.

Stated Meeting, April 21, 1897.

MR. JOHN BIRKINBINE, President, in the chair.

THE SMOKE NUISANCE AND ITS REGULATION, WITH SPECIAL REFERENCE TO THE CONDITION PREVAILING IN PHILADELPHIA.

DISCUSSION.

THE PRESIDENT opened the subject by reference to the circumstance that the Board of Health of the city of Philadelphia had requested the appointment, by the Franklin Institute, of a committee to co-operate with the Board, in considering ways and means for the abatement of the growing evils arising from the increasing use of bituminous coal within the city limits. He announced that Mr. A. E. Outerbridge, Jr., had been invited to open the discussion.

A. E. OUTERBRIDGE, JR.:—In accepting the invitation

of the Secretary of the Institute to open this discussion, I assume that a *résumé* of the scientific investigations that have been made in the past, and a brief statement of the general principles underlying the problem of prevention or abatement of the smoke nuisance, will suffice to indicate the scope of the inquiry which we have been requested by the Board of Health of Philadelphia to make, with a view of offering some practical suggestions to aid that body in preparing a suitable smoke ordinance, should we find it feasible and advisable, for presentation to the Mayor and Councils.

The subject is by no means a novel one, although it is true that factories in America were formerly established, as a rule, in sparsely settled districts, where fuel was cheap and smoke prevention was not an important consideration. The present high price of anthracite coal, compared with the greatly decreased cost of bituminous coal, is now causing manufacturers in this city to reluctantly discard the more costly fuel and to substitute the cheaper, smoke-producing bituminuous coal.

Formerly the smoke-stacks of factories in this city towered high above neighboring buildings, and the smoke, when emitted, was carried away by the winds, causing little annoyance to the neighbors. The development of modern "sky-scraper" office buildings surrounding industrial establishments, far overtopping their chimneys, is rapidly changing these old conditions, and the question of prevention or abatement of discharge of black smoke from the chimneys of such factories within the city limits has now become an important problem, which cannot be longer put aside.

It is not the first time that the services of this Institute have been requested by the city authorities in discussing and solving municipal engineering and mechanical questions. The results of such deliberations have heretofore proved beneficial to the city and creditable to the reputation of the Institute. The present topic is a fitting one for our consideration, and it requires very careful and judicious treatment. The purpose of the foundation of this Institution was, and its motto is: "The promotion of the mechanic arts." It is, therefore, self-evident that no legislation

which would tend to injure or embarrass any of our great industries would be likely to meet with favor. On the other hand, and for this reason, any practical suggestions which we may be enabled to make, looking to smoke abatement, will carry great weight with the City Councils, with manufacturers, and with all people interested in the comfort and health of our citizens, the cleanliness and beauty of our public buildings, private dwellings and streets, and, in a word, in the continued prosperity of this great manufacturing city in the future.

In the course of some investigations made during the past year, I have found that unwise and ignorant legislation has been the chief cause of failure of some of the smoke ordinances which have been passed in several Western cities where soft coal is the principal fuel used.

Here, for example, is an ordinance more than ten years old, making it a penitentiary offence for an individual to permit black smoke to escape from his chimney. I doubt if any such offender (in the city which shall be nameless) has ever been so punished. The very absurd and preposterous nature of the penalty made the ordinance practically a "dead letter" from its inception. Other ordinances in the collection now before you vary greatly with respect to their inherent merits; some are comparatively good, some are positively bad, but all are, no doubt, capable of improvement.

The president of the Board of Health of Philadelphia has been the recipient of numerous complaints from citizens—more especially since the recent large increase in the use of bituminous coal in industrial establishments—of annoyance from smoke discharge, and, wishing to avoid mistakes, has placed the matter in our hands for investigation and advice, and our Board of Managers has wisely concluded, in order to insure a full discussion of the subject, to authorize the secretary to issue a call for a sort of scientific "town meeting," to which a general invitation has been extended.

I am informed that quite a number of gentlemen from this city and elsewhere, who are practically familiar with the subject to be discussed, have accepted the invitation

and are present and prepared to offer their views to-night. I will, therefore, merely give you, in an informal, conversational way, an outline of the subject to be discussed, indicating also the proper road which I think we should travel, and to which we should confine ourselves.

More than fifty years ago the way was prepared in England by the appointment of a royal commission of fifteen distinguished scientists, manufacturers and others, including the Lord Mayor of London, to investigate the subject of the smoke nuisance in that city. A vast amount of testimony was taken, and valuable information gathered from a variety of sources.

Three fundamental questions were formulated and propounded to many persons skilled in the arts and sciences, viz:

(1) Is it practicable to prevent or diminish the discharge of smoke?

(2) Is it advisable?

(3) In the event of an affirmative, answer would you recommend legislative enactment?

The concensus of opinion was that the discharge of black smoke was merely the visible sign of imperfect combustion, and that the time would certainly come when it would be both practicable and necessary to prevent such discharge.

That this time has now come—certainly in so far as it applies to smoke discharge from chimneys of stationary boilers—you will, I think, be convinced by the arguments of various speakers present, who have expert knowledge upon the subject, by proofs they will offer and by the photographic illustrations which will be presently thrown upon the screen, if time permits.

With regard to the practical importance of the subject, I cannot do better than to quote from the admirable report of Chief Smoke Inspector Adams, of the city of Chicago, published in one of the reports of the Board of Health of that city.

Mr. Adams says:

"Viewed from the standpoint of the smoke inspector, the 1,600,000 people of Chicago are divided into two classes: (1) those who create a smoke nuisance; (2) those who are compelled to tolerate a smoke

nuisance. One class has radical champions, who maintain that smoke is an irrepressible necessity—a concomitant of the commercial and manufacturing supremacy of Chicago; that smoke not only is not unhealthy, but that it is an actual disinfectant; that the advocates of smoke abatement are visionary sentimentalists, and, in a general way, they are emphatically opposed to any agitation of the subject."

The inspector gives the other side also:

"They declare that the smoke nuisance is a positive menace to the health of citizens; that it has resulted in an alarming increase in throat, lung and eye diseases; they point to ruined carpets, paintings, fabrics, the soot-besmeared façades of buildings, and to a smoke-beclouded sky, and demand that the smoke inspector do his plain duty under the law."

The Chicago inspector gives some astonishing facts and valuable suggestions. He shows that within the corporate limits of the city there are located 15,000 steam boilers, of which not less than 12,000 are consumers of soft coal. These are scattered over 186 square miles, and no two plants are alike. He says:

"I know of an instance in which a restaurant firm so consumed $600 worth of coal as to cause an actual damage to adjacent property exceeding $25,000. In another instance, an apartment building, under the management of a receiver, protected by the court against the enforcement of the smoke ordinance, ruined the furniture and furnishings of every residence for two blocks in its neighborhood, and depreciated the value of adjacent real estate more than one-third of its former value. * * * Fortunately there exists a growing contingent around which is crystallizing a sentiment that it is practical and possible to abate the smoke nuisance without endangering the stupendous interests involved. The most intelligent and active members are drawn from the ranks of those formerly largely responsible for the smoke nuisance. They now oppose smoke for the same reason that they once defended it; they have made the discovery that it is cheaper to abate a smoke nuisance than to maintain one, and by reason thereof the smoke nuisance in Chicago will be a relic of the past before the close of the present century."

A few years ago the city of St. Louis appointed a committee of disinterested gentlemen (civil and mechanical engineers and others) to investigate the smoke nuisance, and their report is a valuable document, but limited time precludes any other reference thereto.

The problem of smoke prevention may be studied from several different points of view.

(1) The simplest and best solution is, undoubtedly, the use of smokeless fuel. Petroleum is an ideal smokeless fuel, and its qualifications were exploited at the Chicago Exposition, where a battery of boilers of 25,000 horse-power,

fed from fuel oil, piped all the way from Lima, O., excited admiration. The absence of smoke, dirt, ashes, economy, of labor, etc., and beauty of the installation, were the most plainly and conspicuously apparent features. Further examination revealed other merits, thus: 1 pound of petroleum evaporated 18½ pounds of water at 212° F., or more than twice as much as the average evaporation obtained from coal in ordinary boiler practice.

In Russia, where fuel oil is abundant, locomotives, steamships, stationary boilers and private dwellings use petroleum fuel almost exclusively.

In Chicago, upwards of 2,000 barrels of fuel oil are now consumed daily.

Several years ago the Pennsylvania Railroad investigated the subject of fuel oil for locomotives, and sent their chief chemist to Baku, Russia, to study the question at the place where such oil is most largely procured. On his return, this gentleman, Dr. Dudley, said in this hall:

"In the experiments already alluded to on the Pennsylvania Railroad, it was actually found, with oil at 30 cents per barrel, it cost nearly 50 per cent. more to take the same train of cars 100 miles by means of oil than by means of coal."

Dr. Dudley stated further that the oil production in this country was entirely inadequate to supply the place of coal for fuel. The total consumption of coal on the Pennsylvania Railroad, including all its ramifications, was, at that time (1888), about 8,000 tons per day. "If now," said Dr. Dudley, "this fuel consumption was changed from coal to oil, the Pennsylvania Railroad alone would use over 26,000 barrels of oil per day, and this 26,000 barrels is over one-third, and at the present time nearly one-half of the daily oil production of the United States; so that lack of supply, in this country at least, will, for a long time to come, prevent the use of oil in anything more than a very limited way. In Russia, no difficulty of this kind occurs, and for two reasons:

"First, because the oil supply is enormously greater than it is here. When I was in Russia it was credibly stated

that a new well had been struck, which actually flowed more per day than the total daily production of the United States.

"The second reason is that the nature of the Russian petroleum is entirely different from American. With the largest portion of American petroleum, 75 per cent. is capable of being made into refined oil, leaving 25 per cent. of residues. In Russia the figures are exactly reversed —25 per cent. only is made into refined oil, 75 per cent. is residues. These are what is burned. They have a fire test of about 320° to 340°, and look, and are, in truth, very much like our ordinary reduced petroleum, known in the market as 'well oil,' and used for lubrication."

Notwithstanding the fact that the Lima fuel-oil fields have been discovered since Dr. Dudley's address was delivered, events have proven the correctness of his predictions, and we may as well abandon the idea of the probability of the general use of petroleum as fuel in this country.

(2) The use of anthracite coal is too well known to require more than passing mention, but it is an unfortunate fact that this admirable fuel has proven unable to compete successfully with bituminous coal in the race for industrial supremacy, for several reasons. The anthracite coal belt is confined to Pennsylvania; the surface croppings have become exhausted, the veins have been followed deeper and deeper into the bowels of the earth, and the cost of mining is consequently constantly growing larger. Since 1880 the output of anthracite has doubled, but in the same time the production of bituminous coal has almost quadrupled, and new sources of supply of the latter fuel are being continually uncovered and developed all over the country.

In 1895 (the latest date for which I have obtained official data) the total output of coal in the United States reached the enormous amount of 172,426,366 long tons; the bituminous output was 120,641,244 tons, the anthracite production was 51,785,122 tons.

In 1880 the production was (in round figures): Bituminous, 38,000,000 tons; anthracite, 25,000,000 tons. Thus the anthracite output in 1895 was double the output in 1880,

while the production of bituminous coal was more than three times as great as in 1880.

In London and in our Western cities, where bituminous coal is used almost universally in households, the smoke-abatement question is much more difficult of solution than it is in Philadelphia, where anthracite is exclusively used (except in a few open grates) in families.

Since the disruption of the soft coal pool and consequent great reduction in price of bituminous coal,* many manufacturers in this city who formerly used anthracite—on account of the avoidance of smoke—have been compelled to change to bituminous fuel.

The last annual report of the United States Geological Survey (1895-96) contains a table showing the amount of anthracite and bituminous coal received, exported and used in Philadelphia in 1894 and 1895. This gives the "local" consumption of bituminous coal in those years as 845,000 tons and 1,060,000 tons, respectively, and of anthracite 3,540,000 tons and 3,960,000 tons.

Since the beginning of the present year the increase in the local use of bituminous coal has been most noticeable, for the reasons already given, and I heard, to-day, on reliable authority, of an instance where a single customer, a large concern in this city, which purchased of the Reading Coal and Iron Company 100,000 tons of anthracite last year, and approximate amounts in former years, has not bought any anthracite coal this year. The reason is obvious and the effect is also apparent.

(3) Smokeless combustion of bituminous coal.

It was my intention, if time had permitted, to illustrate my remarks with a simple, practical demonstration of the cause of black smoke production from distilling or imperfectly consuming bituminous coal, and to show methods of prevention of smoke, but, in view of the rapidly-passing time and

* The *Railroad Gazette* of April 2d, referring to this matter, says: "It was a scramble for tonnage, in which prices had secondary consideration, and it is very difficult to quote prices to-day, as they are largely a matter of bargain. The nominal quotation is $1.90 at Norfolk, Newport News and Philadelphia, with 10 cents differential in favor of the Clearfield region."

of the number of speakers who are to follow me, I will not occupy more of your attention at present, but will close my address with the statement that the result of my own investigations of the subject of the smoke nuisance from burning bituminous coal is, that the problem of its abatement has been—in so far as relates to stationary boilers—practically solved, and that, in the present state of the mechanic arts, the emission of dense black smoke within city limits should not be permitted, because it can be practically and economically obviated.

DR. R. H. THURSTON [Correspondence]:—I have had very little to do in a business way with the matter which is here considered; but the subject is one of interest to every engineer, and I have, as a matter of course, studied it somewhat and, in the course of a now somewhat extended professional career, have seen something of the practical side of the economical question involved. It is, in fact, a matter largely of finance. The nuisance is certainly capable of substantial, if not of absolutely complete, abatement, as was shown a century ago by Watt, when he produced the first "down-draught" furnace, and by hundreds of others, up to the time of Charles Wye Williams, and later investigators who have experimented with various expedients involving the efficient use of the dead-plate, and the employment of specially arranged air-ducts, bringing fresh air into the furnace at a point at which the smoke, once formed, could be consumed, or, more correctly, I have no doubt, by which its formation could be prevented, by insuring the complete combustion of the bituminous fuel at the critical place and time.

The preventives which operate more or less effectively may be considered in the following order, viz.: Legislation, Skilful Operation of Furnaces, Special Constructions of Furnaces.

Legislation may be made effective, simply because it is actually practicable to-day to suppress the nuisance by means available to all. I am inclined to believe that the most effective form of legislation is that which operates through the Boards of Health of the cities. By this I do not

mean to intimate that the "smoke nuisance" endangers health in any ordinary case; on the contrary, I am inclined to think that the presence of this, which is always a minute amount of free carbon in the air, is rather healthful than otherwise; but it unquestionably is a nuisance, nevertheless, and possibly such healthful and aseptic influence as it has may be more than counteracted, in ultimate value, by the malign influence exerted on morals and manners, and against that cleanliness which is next to Godliness.

Boards of Health, however, seem to be the proper agencies through which to bring about this particular reform. There should be, in every city, municipal regulations compelling the officers of the municipality to keep constant supervision over this, as over all other nuisances, and to report every case of evident infraction of the law. Then, if, after ample warning, the nuisance is continued, the Boards of Health should be empowered to take steps toward the summary extinction of its source.

The fines inflicted, under the usual system of suppression, should be such as would make the employment of fuel in such manner as to produce notable amounts of smoke more costly than the use of smokeless fuels. Perhaps the most effective and simple system of fines would make the assessment a stated sum per month per square foot of grate-surface of boilers employed, and during the periods throughout which infraction of the regulations of the city can be proved. At 15 pounds burned per square foot of grate per hour, for a working year of 3,000 hours, about 2 tons of fuel will be consumed. The difference in costs of bituminous and anthracite coals being taken as, we will say, for illustration, $2 per ton, the proprietor can bear a tax of that amount, if it should prove necessary, on the part of the city, to impose it; and this means about $4 per annum per square foot of grate surface. A fine of 25 to 50 cents a month per square foot of offending grate will thus, presumably, abate the nuisance under such circumstances. Very likely a much smaller sum may prove sufficient; but that is a matter for trial, and one to be settled by experience.

In imposing fines, I should propose that they be gradually raised from some comparatively small minimum, by easy increments, to the maximum just indicated. Very probably a fine of 5 cents a month per square foot of grate, for cases reported, with publication of the reports in the daily press, would extinguish a considerable proportion of the smoke. Increase to 10 cents would reduce the offenders to comparatively small numbers; 20 cents might, perhaps, shut down substantially all of the well-disposed, leaving a few obstinate cases, or cases of peculiar difficulty from the standpoint of engineering, to pay the full cost of smokeless fuels until the changes required could be effected. So far as my own observation and experience go, this system of gradual extinction of the nuisance works by far best.

The methods of reduction of smoke are well understood by every member of the engineering profession familiar with steam-making practice. They all accomplish the result in substantially the same way—insuring ample air supply and amply high temperature for ignition at that point on the surface of the fuel bed at which decomposition, without ignition, would otherwise occur. Air supply in excess at the bridge-wall, or at some neighboring point, is a common expedient. The gradual coking of the fuel, when first thrown into the furnace, on a "dead-plate" near its mouth, is a practice as old probably as the steam engine. The recent forms of mechanical stokers seem to me, though not always successful, to be, in some cases, peculiarly well adapted to secure smokeless combustion. The "down-draught" furnace, invented by Watt, and improved in modern times and by contemporary inventors mainly, is one of the most interesting and curious of the later systems of combating this nuisance. There are now so many methods and so many forms of apparatus which are capable of more or less completely preventing smoke, that where there is a will, the only obstacle to success in finding the way lies in the financial aspect of the case. Both the methods and the apparatus needed are now available and well known.

In some of the Western cities, St. Louis notably, the success met with in the reduction of the smoke nuisance

has been most satisfactory and encouraging. I think that even the city of Pittsburgh is profiting by these modern ideas to some extent, for it is certainly not as smoky a city since its return to the use of coal as before it was blessed, temporarily, by ample supplies of natural gas.

The quantity of fuel lost in smoke is too small to make its reduction important as a matter of simple economy. Experiments in the Sibley College laboratories, about two years ago and since, have shown that, under the conditions of those experiments, at least, it was possible to produce, "deliberately and with malice prepense," the densest smoke being secured that was practicable, about 15 pounds of soot per ton of fuel employed. The usual figures for dense smoke ranged from 10 to 12 pounds. Of this soot about one-half was carbon, the remainder mainly unconsumed hydrocarbons, 10 to 15 per cent. of ash and, if collected outside the furnace, perhaps 2 per cent. of moisture.—Gilbert and Flory, in *The Sibley Journal of Engineering*, May, 1895.

It was found that no smoke was ever produced in an atmosphere of oxygen. With restricted air supply the maximum just stated was obtainable. Low temperature combustion and restricted oxygen supply seem to be the two main conditions favoring smoke production. Singularly, as it seemed to me, the composition of soot was found often to be substantially that of the coal from which it was produced. A reduction of the proportion of smoke made effects a reduction correspondingly, perhaps proportionately, in the percentage of carbon contained in the soot. Thus coal used at St. Louis was found to contain 50 per cent. carbon, 36 per cent. hydrocarbons. Its smoke contained 25 per cent. carbon and 10 per cent. hydrocarbons. Where no hydrocarbons exist, smoke cannot be produced by any fuel. It is evident that in the average case we cannot expect reduction of smoke to result in economy of fuel or of expenses. It will cost more to extinguish smoke in most cases probably than can be gained by its suppression and its utilization as fuel.

In Circular No. 7, of the Steam Users' Association, of Boston, the statement will be found, supported by evidence,

that "stokers" save smoke in all cases. The prime advantage of this system, as it relates to the reduction of waste by smoke and incomplete combustion, lies in the fact that, with continuous and steady operation, the adjustment of the air supply, the depth of the fuel bed, and, in fact, of all the variable conditions of combustion, become practicable, each being gradually brought to its best adjustment; and, finally, all conditions being made those of best effect and then so retained, without difficulty, in such manner as to insure the utmost possible efficiency. Where, as in ordinary hand-firing, the conditions of operation are never the same for five minutes at a time, it is evidently impossible to insure correct adjustments or conditions of maximum efficiency at any instant, much less to preserve them through the working day.

In firing anthracite on board ship—which happens to be the practice with which I have been specially and practically most familiar—I have found this to be the fact also, and the steadier the condition of operation the better the result. This maximum steadiness is, in this case, brought about by regular firing, and at rather frequent intervals, the furnace door being opened, by the attendant coal-passer or by a neighbor fireman, only during the instant that the shovelful of coal is going in and the fireman is getting his glance at the best spot for the next; thus preserving the intensity of the fire by thin firing and restricted influx of cold air, either through the door when firing or through holes in the fuel bed.

Precautions against reduction of the temperature of the furnace by too close contact with the comparatively cold surfaces of the boiler is, I think, sometimes a matter of more importance than is generally assumed or realized. Some constructions of the steam boiler, unsuccessful at first in a soft-coal market, have been made more successful, if not completely so, by enlarging the furnace-volume and by protecting the fuel-bed from loss of temperature by direct radiation, the protection being afforded more or less completely by brick arching and by lining.

The general principle governing this, as almost every other phase of boiler efficiency, may be stated to be:

Secure maximum temperature of furnace, producing the total heat of combustion, as nearly as practicable, before commencing to take off heat for application to steam-making. *First*, make the work of developing the heat of combustion perfect, *then* transfer that heat to the point at which it is to be used. Maximum temperature of furnace insures chemical union, if the combustible and the supporter of combustion are present in proper proportions, and the securing of proper proportions then becomes the one essential requirement for success.

I am inclined to expect highest efficiency, ultimately, through the use of the mechanical stoker, after "the survival of the fittest" shall have shown which of the many and ingenious existing forms is best suited to use with each of the type-fuels of the country.—[SIBLEY COLLEGE, CORNELL UNIVERSITY, April 19, 1897.]

MR. WILLIAM R. RONEY:—I appear before you to-night as a substitute for another speaker, who, being unable to come, asked me to take his place. Having but short notice, I fear I will not be able to add much to what has already been said, but will, however, venture a few remarks.

The production of smoke from bituminous coal is one of the results of imperfect combustion. That it should be prevented, no one will question; that it can be, few will doubt. The problem for the engineer and those connected with industrial interests to solve is, how to do this, and, at the same time, secure the highest economic results from the coal burned.

I hardly need state before an audience of this character that there are four requirements for complete or smokeless combustion, but to make my remarks better understood, I will name them, viz.:

(1) Sufficient air to supply the necessary oxygen.

(2) A thorough mingling of the oxygen with the volatile gases.

(3) A constant high temperature of air and gases; and

(4) A uniform supply of fuel, regulated according to the demands for heat for steam-making or other purposes.

If these conditions are present in the furnace, we have

complete combustion and no smoke. To accomplish all this is difficult with the ordinary hand-fired furnace and the average fireman, but with a good mechanical stoker and a fireman of ordinary intelligence, it can be accomplished and bituminous coal may be burned without smoke.

The first condition, namely, a sufficient air supply, is necessary for either flat grates or stokers, and requires a good draft, natural or artificial, which can be secured by a tall chimney properly proportioned, or by the use of mechanically induced draft apparatus.

The second condition of a thorough mingling of the air and volatile gases exists in a hand-fired furnace when the fire is new and clean, and the air can pass freely through the bed of burning coal, but after it has burnt a while the ash and clinker accumulates next to the grate from the constant spreading of fresh coal on top of the fire, and the quantity of air passing through the grate is very greatly lessened, and the economy also seriously affected. But with a mechanical stoker having moving grates, the contrary is true, as the motion of the grate bars keeps the fire clean and open and permits a constant and free circulation of air.

The third condition, namely, a constant high temperature of the air and gases, cannot be obtained with a hand-fired furnace, as the frequent opening of doors for cleaning and firing causes an inrush of cold air, which quickly lowers the temperature of the furnace below that required for the ignition of the gases—about 1,000° Fahr.—and the carbon is precipitated in the form of finely divided particles of soot, which roll out the chimney as smoke. On the other hand, a mechanical stoker, properly designed, can be operated continuously without the opening of doors, and the initial temperature in the furnace maintained at as high a point as is necessary for perfect combustion. Mechanical stokers have been applied to reheating furnaces in rolling mills, and a temperature of over 3,000° Fahr. has been maintained for many hours at a time.

The fourth condition of a uniform supply of fuel is equally as important as the other three. Here is where the mechanical stoker is especially successful. The average

hand-fireman fires in the way that he thinks will be easiest, which generally consists in piling in the coal until the furnace will hold no more, and then sitting down and letting it smoke. Even with skilful hand-firing, the supply of coal is necessarily intermittent. It is, of course, possible to fire by hand and produce practically no smoke, by firing often and in very small quantities; but this is hard work and requires intelligence, and it is not easy to find men who will do it for the average fireman's wages. If they have the necessary brains, they will not stay in the boiler room, but will seek a more desirable place and better pay. The result is that, as a rule, we have a very inferior class of men in the boiler rooms, and it is not strange that the results of average hand-firing are so unsatisfactory, both in economy and smokelessness.

A mechanical stoker of simple design, operated by the ordinary fireman, will give a uniformity in fuel supply and freedom from smoke unattainable by the most skilful hand-firing; and with the proper draft will develop a large increase in capacity over hand-firing, and do so without smoke. The forcing of hand-fired boilers is a prolific source of smoke, as to do this requires frequent slicing and stirring, causing large quantities of the volatile gases to escape up the chimney unburned, to pollute the atmosphere and reduce the profits of the man who pays the coal bills. This nuisance and loss can be prevented, and I believe mechanical stokers are the surest means for accomplishing it.

Another cause of smoke is the fact that very few boilers have sufficient room for the combustion of the gases from bituminous coal. Many boilers are set so low that almost as soon as the gases are released from the coal, they impinge on the cold shell of the boiler, lose their heat and pass up the chimney as smoke. Great numbers of boilers were originally set to burn anthracite coal, and when the change was made to bituminous, no change was made in the setting which provides less than one-third the combustion room required by bituminous coal. This is a very common fault with boilers in New England, where, up to a few years ago, anthracite coal was burned almost entirely. This

difficulty is completely overcome by mechanical stokers of the inclined grate type, as the large combustion chamber, combined with the uniform supply of coal and the gradual distillation of the gases in the coolest part of the furnace, presents conditions most favorable for complete and smokeless combustion.

If you wish to secure the co-operation of those who burn bituminous coal, and to enlist them on the side of smoke prevention, you must be able to show them that the saving in fuel will justify the cost of apparatus to prevent smoke.

The loss in fuel by the production of smoke, is principally due to the invisible gases which escape up the chimney unconsumed, and which, together with the carbon in the smoke, frequently represent a large percentage of the heat value of the coal. I have done considerable engineering in connection with mechanical stokers during the past twelve years, and know, from observation and experience, that they will not only give smokeless combustion, but effect a saving in fuel and labor which will pay a large percentage on their cost. They will save in fuel 10 per cent. and upwards over average hand-firing, which, at the present price of coal in Philadelphia, is fully 25 per cent. on the cost of the stokers. Where the plants are large enough to require more than one fireman, there will be an additional saving in labor.

If such facts are properly presented to those who are making smoke, it seems to me that there should be but little difficulty in convincing them that it is for their interest financially, to say nothing of their civic pride, that they use well-known and proven means to abate the smoke nuisance in this city.

PROF. L. M. HAUPT [Correspondence]:—In response to your suggestion that I would contribute to the discussion of the smoke nuisance question, I would submit that, as the unconsumed carbon is simply waste, it would be to the interest of all parties to prevent its escape. This can be largely effected by more intelligent firing, whereby a larger amount of oxygen is admitted over the incandescent

material, instead of being forced through it. This was very forcibly impressed on me whilst riding on an engine in Ireland, where the fireman fed his fuel in small quantities well distributed and left the upper door ajar. We made 60 miles an hour with a heavy train, and only a thin white smoke was emitted from the stack.

I have requested Col. Thos. P. Roberts, of Pittsburgh, to give his experience, and have received from him some printed data (sent herewith) which will prove of interest in the discussion of this important subject.—No 18 South Broad Street, Phila., April 15, 1897.

Thomas P. Roberts (Correspondence):—I am in receipt of your letter of the 10th inst., asking for my views as to the smoke abatement question in Pittsburgh, and especially with reference to the effect of the city ordinance bearing on the subject.

This is a matter to which, several years ago, I gave considerable personal attention, from the fact of having served on committees of the Engineers' Society of Western Pennsylvania and of the Chamber of Commerce, to which the subject had been relegated. For the last four years, however, I have had time only to be a casual observer of the progress that is being made, and, very often, I have been in the predicament of wondering how any real progress in smoke abatement was being made, while, monthly, there was a palpable increase in the visible supply. This is not a paradox, however, when all the facts are considered. On this point, however, I believe I can safely say that we have passed the maximum point of the smoke nuisance in Pittsburgh, and, like the National pension list, it must continue henceforward to decline, and ultimately to disappear.

Pittsburgh, before the days of natural gas, *i. e.*, prior to 1883, was the very lions' den of smoke. Our people had become so accustomed to it as actually to take some solace to themselves from the statement of English travellers, which accorded us the palm even over London. Rarely, indeed, in those days were the hills across the Monongahela River visible from Water Street, one-third of a mile distant, and vegetable life beyond the ailanthus tree struggled in

vain as a beautifier of our streets. With the introduction, about 1883, of natural gas, an impetus was given to the sun-worshippers, and their doctrine of light and cleanliness spread with remarkable rapidity. For several years it was possible, from the roofs of the taller buildings, to look over the entire commercial part of the city, and see not a vestige of smoke, and, generally speaking, the atmosphere was as clear as it ever was over Boston, New York or Philadelphia.

With the decline in the yield of the gas wells and the return to the use of bituminous coal under boiler fires, organized efforts were made to have introduced in Pittsburgh, as far as practicable, smoke-consuming devices. The Engineers' Society, the Chamber of Commerce, and several ladies' organizations, became very energetic in this work, and finally their efforts resulted, in 1895, in the passage of the city ordinance. This ordinance* is, however, almost

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*AN ORDINANCE—No. 1263—To regulate and suppress the production and emission of smoke from bituminous coal, and to provide penalties for the violation thereof in the city of Pittsburgh. Approved May 22, 1895.

SECTION 1. *Be it ordained and enacted by the City of Pittsburgh, in Select and Common Councils assembled, and it is hereby ordained and enacted by the authority of the same, that* on and after October 1, 1895, the emission of more than 20 per cent. of Black or dark Gray smoke from any chimney or smoke-stack where bituminous coal is used as fuel in connection with boilers for heating and power purposes, shall be deemed and is hereby declared to be a public nuisance.

SEC. 2. That it shall be unlawful for any Corporation, Copartnership or Individual owning, controlling or using any chimney or smoke-stack used in connection with boilers within the city limits as provided in Section 1, to allow, suffer or permit smoke from bituminous coal to be emitted or to escape therefrom.

SEC. 3. Any Corporation, Copartnership or Individual who shall or may allow, suffer or permit smoke from bituminous coal to be emitted or to escape from any chimney or smoke-stack used in connection with boilers for over three minutes' duration at any one time, shall, in addition to any and all laws requiring the abatement of nuisances, forfeit and pay to the City of Pittsburgh for every such offence, a sum not less than ten ($10) dollars or more than fifty ($50) dollars to be recovered before any Alderman of the County of Allegheny or any Police Magistrate of the City of Pittsburgh as debts of like amounts are now recoverable.

SEC. 4. No discrimination shall be made against any device or method which may be used which will accomplish the purpose of this ordinance in relation to the said matter.

as smoky and obscure as the subject to which it relates. Sections 1, 2 and 3 conflict with themselves, and altogether, it is so illy constructed that it may be doubted whether there could be any successful prosecutions under its terms. The councils of no manufacturing city would be wise in entering too boldly upon such a field as this. If the edict reads "let there be no smoke," at least practicable means should be pointed out how to maintain fires without its production. The lack of precision and general weakness of the ordinance may, after all, have been for the best. There has never been a desire to employ unduly oppressive measures against offenders in Pittsburgh, and it has rather been the policy of the Department of Public Works, which has the enforcement of the ordinance in charge, to be as lenient as possible, and, through educational work and experiments at the pumping stations, to demonstrate that fuel bills might be reduced by proper methods of smoke consumption. Thus it is just now that Pittsburgh is a permanent exposition of smoke-consuming devices.

After two years' experience, a disposition has, at last, been manifested to take further and rather more stringent steps in the direction of a more decided reform. It is felt, however, that State legislation is necessary before any more decided movement is inaugurated; but in what way State laws are to be invoked, I am not, at present, informed.

I called at the Department yesterday, and had a brief talk with some of the officials, and was greatly pleased with what I learned, and I would advise the Franklin Institute to send a representative, or a committee, to Pittsburgh, and learn what has been accomplished by the smoke inspector and his two assistants. Here, also, examples of all the best, as well also of some of the worst, smoke-consuming devices could be examined, and I have no doubt that the officials in the Department at City Hall would extend every facility to inquiring visitors.

SEC. 5. **The Director of the Department of Public Works of the City of Pittsburgh is hereby empowered and directed to enforce the provisions of this ordinance.**

SEC. 6. **That any Ordinance or part of Ordinance conflicting with the provisions of this Ordinance be and the same is hereby repealed so far as the same affects this Ordinance.**

The Pittsburgh ordinance applies only to boilers used for heating and power purposes. The day for consumption of smoke from domestic fires has not yet arrived, not because the demand for it is weak, but simply because of the fact that no universally applicable system or device for its consumption has yet appeared.

I understand that about 400 firms or establishments have already complied with the law in Pittsburgh, either in whole or in part. In office buildings, the Roney, the American and Brightman stokers are chiefly used, while some of the large street-car line power-houses use the Murphy stoker. In one of the largest steel works, where 20,000 horse-power is developed and 114 steam boilers are in use, about 70 of the boilers are now equipped with the Black Diamond stoker, and the firm is so much pleased with them that they are about to place them under all their boilers.

I have very frequently seen, most excellent—I may say magical—results from the simple use of steam jets in the abatement of smoke. From some inquiry as to late experience I am led to believe that, when properly applied, steam jets are a positive and certain cure for even the smokiest of fires. There are situations where, from cramped positions, as in basements of buildings, and inefficiency in size of boilers, not sufficient draft can be secured for complete combustion, steam jets would do the work where no form of mechanical stoker would give satisfaction. A friend who has studied the matter, himself a former engineer in the U. S. Navy, states his belief that the use of steam jets is in no way injurious to boiler sheets, a point concerning which I had some apprehension. They were not, however, in his opinion, economical, *i. e.*, they were not coal savers, but ordinarily did not increase the consumption of the fuel over ordinary hand-stoking. Their lack in economy was more than compensated for, according to my friend, in the greater reliability and efficiency of the boilers in rapid steam production. I was told of a case in this city, where a 65 horse-power boiler was worked to 250 horse-power, yet with steam jets it produced little or no smoke. Much appears to depend upon the angle with

which the steam jets are set. The best practice here, I was told, was to arrange the jets about a foot apart, the orifices being $\frac{1}{32}$ of an inch in diameter.

The great trouble in Pittsburgh, and I suppose the same is true in other cities, is that the boilers are too frequently overtaxed. Architects are, also, much to blame for providing such scanty room for boilers in buildings. In fact, the boilers are generally placed in the very darkest corners, in places the owners seldom care to visit—and would see little if they did visit. To manage the boilers, an "engineer" (heaven save the mark) is engaged at wages that, with difficulty, will keep him alive. It has been asserted here by steam experts that men can be produced in Pittsburgh who will manage certain batteries of boilers with hand-stoking, guaranteeing to show up clean "smoke shade" cards, and who would accept for their pay the monthly saving in coal bills they could effect. But it appears that even capital and brains, as well as labor, run in such ruts that nothing startling is ever tried. The abatement of smoke seems to be especially one of these matters of public interest where everybody is hopeful regarding its future, but where everything drifts slowly. No matter how much we may wish for a revolution here, it will come only through the slower process which the omission of one letter of the word makes, viz.: evolution.—PITTSBURGH, PA., April 13, 1897.

D. ASHWORTH & SON, Pittsburgh, Pa. [Correspondence]: —In compliance with the request of your Secretary, we would present for your discussion of "The Smoke Nuisance and its Abatement," with special reference to your city, a few observations that we have noted from the practice in the West.

The subject of smoke prevention (or, more correctly speaking, smoke abatement) is one that has elicited much discussion and the earnest consideration of engineers, as well as those whose interests are in the commercial industries that suffer most from the growing evils in this direction.

In large cities the difficulties encountered by the engineer who endeavors to abate the smoke nuisance in an old

plant lie principally in the cramped condition of the boiler-room and the lack of provisions by architects for the increase in boiler plants. Not only do we find this condition presenting itself in old plants, but the oft-repeated lesson is disregarded by many architects, and we may find to-day many buildings under erection where no means is left for the enlargement of the power plant.

The loss of power which is attendant on the application of such furnaces as involve the use of steam jets is a serious consideration to plants that are running on the very margin of their utmost capacity. We are aware that many companies present tests showing an increased efficiency due to furnaces of this type; but in no test thus presented to us for consideration, nor in many tests that have been published, have the engineers deducted the amount of water that should be charged to the furnaces. We know this to be an important item from comparative tests we have made, in which the steam supplied to jets has been supplied from another source than the boilers under test, and in which the results have shown a marked decrease in the efficiency of the boiler.

Mechanical stoking, if intelligently handled, will aid greatly in abating the smoke evil. Some stokers will aid the plants that are running at their maximum; but in installing new furnaces under old boilers, from lack of careful study of local conditions, the results are more often of a disappointing nature.

Numerous devices, such as water arch, brick arches, the admission of air at the bridge-wall, etc., have made good records as smoke abaters; but with any of these it may safely be said that without careful firemen, of sufficient intelligence to study their fires and conditions, satisfactory results cannot be obtained. We cannot lay too much stress upon the importance of intelligent firemen, and for the fact that there are so many men firing boilers with no other thought than to shovel in coal, the responsibility lies with the lack of appreciation of their employers, who are of the opinion that any laborer can shovel coal, and remunerate him accordingly.

When the subject of smoke abatement has provoked sufficient interest as to warrant legislation, it is to be hoped that the matter will be placed in the hands of engineers who are competent to aid and instruct the people who are offending, by pointing out ways in which they may improve their plants, and not in the hands of clerks with the idea that any one can tell when a stack smokes. This is not what they need. What they require is an honest, unbiased engineer, who can show them that the stack not only smokes, but why it smokes, and how to stop it. Some cities have such men, but others are not so fortunate.

We are firmly convinced that great strides may be made in Philadelphia in the way of smoke abatement, without imposing burdensome restrictions upon commercial interests and that the results that will accrue will greatly benefit the city.

MR. EDWARD LONGSTRETH [Correspondence]:—In reply to an invitation to contribute to the discussion of the smoke nuisance question, I beg to submit as the expression of my opinion, a communication which I addressed, on March 18, 1891, to a committee of the Councils of the city of Philadelphia, viz.:

"Having been asked if the black smoke coming from locomotives by the use of soft or bituminous coal can be burned, I would say, do not make it, but burn the particles of carbon as soon as they come in contact with the fire. This can be done with a little care on the part of the fireman; he must keep a thin, bright fire, and scatter the coal as it leaves the shovel over the fire, and fire often, then very little smoke will be seen.

"Distilling smoke from coal and throwing it into the air is a great waste of fuel, as the black smoke is carbon—the most valuable part of the coal. The way to make an engine smoke is to fill the fire-box full with coal, and then let the fireman sit in the cab for the next half hour, then fill up and smoke again. Smoke from an engine is due to careless or ignorant firing. Thirty years ago, when they changed from burning wood to coal on locomotives, I had a great deal to do with numerous devices pat-

ented to consume smoke, but they soon passed out of existence, as it was found the plain fire-box with brick arch and a good fireman showed less smoke than the best patented boilers fired with a bad fireman.

"Watch the trains and you will often see one section not showing smoke, and perhaps with the next section of the same train the locomotive will fill the neighborhood with black smoke, the engines being the same and burning the same coal, but one having a better fireman than the other. In England they fine the engineer and fireman for carelessness if they let an engine smoke.

"The engines are all right (if they tear up a light fire, put in larger exhaust nozzles); educate the fireman and see that he does his duty, then the road will be richer and the neighbors happier."

In confirmation of the opinion stated in the foregoing, I would draw attention to the following communication, which appeared in the *Chicago Herald* of May 18, 1892, and which is self-explanatory, viz.:

"The warning recently given the railroad companies that they would be prosecuted for maintaining a smoke nuisance, if they did not apply some smoke-preventing device to their locomotives in 100 days, is having a salutary effect. The Michigan Central Railroad has 45 locomotives and switch engines in use on its Western Division. All except 8 of these are producing no smoke.

"The company spent thousands of dollars in testing patented devices, but found the best success at last in the use of unpatented air, introduced to the fire-box in a very simple manner. It comes so near preventing all smoke that the company is in no danger of prosecution or excoriation.

"The fact that a great railroad corporation will unbend sufficiently to abolish an offence to the public without compulsion is noteworthy, and the spirit in which this particular nuisance has been abated is commendable. The example may well be followed by owners of stationary engines, with which the problem of the smoke nuisance is much more easily solved. If every man were willing to

prevent smoke, half the battle against the nuisance would be over at once."—PHILADELPHIA, April 20, 1897.

MR. SAMUEL M. VAUCLAIN:—I did not come prepared to speak at length upon this subject, and have arranged no data for the purpose. The Baldwin Locomotive Works, however, with which I am connected, is one of the largest consumers of coal in this city. Several years ago we used, principally, the best grades of anthracite coal for steam-making and furnace purposes. We not only have stationary boilers furnishing steam for operating our plant, but we have, as well, large heating furnaces requiring a very high temperature, and also cupolas for the melting of irons. It became necessary, on account of the enormous outlay that we were making for fuel, to endeavor, if possible, to effect some economy in that direction, so as to reduce our running expenses; and we very naturally turned to the use of bituminous coal. We used a great deal of bituminous coal, which was well suited to the boilers and furnaces, as we had them in operation at the time.

The result of this change, however, was not a satisfactory one so far as the dirt and smoke and consequent nuisance to the neighborhood were concerned. The financial result, however, was very satisfactory. Our boilers were not adapted to the economic burning of refuse anthracite coal, and, in order to abate the smoke nuisance and effect a still further economy in our expenditure for fuel, we decided to use the low grades of anthracite buckwheat coal which were being put upon the market at that time.

In order to do this, we threw out our entire plant of boilers, some of which had given us long years of service, and we could very well afford to dispense with them, substituting in their place the most modern types of water-tube boilers, all fitted with first-class automatic stokers for the mechanical firing of the fuel.

The adoption of automatic stokers was made in order to save a large portion of the labor then employed in firing our boilers by hand, and also to effect a more thorough combustion and more thorough consumption of the fuel as it passed from the bins to the grates and from the grates to

the ash-pans. As an instance of this, one battery of boilers that we have in service—of 1,600 horse-power—requires but one fireman and a cleaner. The fireman's duties are to see that the stokers are always working properly, and that the water is fed to the boilers in a proper manner. The duties of the cleaner are to keep the place clean and polish up the bright work and see that the paint work is kept in order at all times. Both of these men have a very easy and comfortable time, and the steam is furnished at the minimum cost for fuel and absolutely without smoke.

At the present prices at which bituminous and anthracite buckwheat coal are sold in the city, we are able to effect a slight economy by the use of this class of fuel over the use of bituminous coal; in other words, we get more work from a dollar's worth of anthracite than from a dollar's worth of bituminous coal.

In our heating furnaces, an attempt to use the bituminous coal gave us very unsatisfactory results, so far as cleanliness and annoyance to our neighbors were concerned. It soon became evident that to continue the use of soft coal would not only call forth the protests of our immediate neighbors but also the opposition of the city fathers.

The idea then occurred to me that if we could mix that fuel with other fuel in some manner that would permit it to stand open—in other words, separate the particles of fuel so that the air could get at it properly—we would get more nearly perfect combustion with much less discharge of smoke.

The experiment was made by mixing 50 per cent. of anthracite pea coal with the bituminous coal, and the result was very satisfactory indeed, causing an almost entire cessation of the smoke from these furnaces, of which we have a great number congregated together in a very small area. We have been following this practice now for several years with great satisfaction, and have not only, as I have said, avoided nearly all of the smoke nuisance, but have also effected quite a marked economy. It is, therefore, evident that, with ordinary care and judgment, soft

coal can be satisfactorily used by mixing it with anthracite coal, and nearly all of the smoke avoided.

In regard to locomotives, to which you no doubt expect me to refer in my remarks, I beg to say that this is quite another question. The consumption of anthracite coal, of course, produces no smoke, but whether bituminous coal can be burned in a locomotive fire-box without making smoke is, of course, the important question to be decided. It is a very easy matter for one to say that this can be accomplished by careful firing, and opening of the fire-door, and in various other methods heretofore alluded to.

In my opinion, however, the question of satisfactorily avoiding the smoke from locomotives depends upon the amount of coal that it is required of the locomotive to consume per square foot of grate surface every hour. If the locomotive is so constructed that this amount is excessively high, it is impossible to avoid the making of smoke, which occurs from incomplete combustion. Forced firing on a locomotive is not only hard on the fireman himself, but on the bank account as well, as the evaporative efficiency of the fuel is very much reduced, and, consequently, the objectionable emissions from the smoke-stack are very great.

Of late years, the practice at the Baldwin Locomotive Works, where we design locomotives for burning all grades of fuel, has been to have samples of the coal, which is intended to be burned in the locomotives, submitted to us. We carefully analyze this fuel, and then decide as to the proper dimensions for the fire-box, and provisions for the admission of air over the fire, so as to avoid, as far as possible, the emission of black smoke; or, in other words, to arrive at as near perfect combustion as it is possible for us to do.

The personal equation, however, on a locomotive, is a somewhat large one. The fact that one locomotive will make no smoke in starting a train out of a station and passing through the suburbs of the town, and that another of the same class and type, immediately following, will emit

great volumes of black smoke, is sometimes due to the fact that the second engine has been hurriedly called upon to do this service, and the fireman has not had sufficient time, to use a common expression, to "burn a good fire," or, in other words, to get his fire in proper shape before leaving the station. If the fire be in proper condition before he leaves the station, he will have no occasion to put large quantities of fuel in the fire-box until after the city limits have been passed, but if the fire has not been properly prepared, he must get to work at once to furnish his fire with fuel and build it up; otherwise, the fire that he had when he started will be destroyed by the action of the engine, and it will be rendered practically unfit for service, or at least to maintain its schedule speed until he has had an opportunity to recover the fire and get it in good shape. It is, therefore, very easily understood why in some instances a great deal of supposedly unnecessary black smoke is made in starting trains.

The chief qualification necessary in a locomotive for burning bituminous coal is to have a sufficiently large grate area to give an economical coal consumption per square foot of grate surface per hour. This condition is found in what is known as the Wootten boiler, or Wootten fire-box, as now used by a great many of our leading railroads for burning refuse coal of all grades. At the present time we are changing twenty-five narrow fire-box locomotives and fitting them with Wootten boilers, or fire-boxes, for this purpose, for the Erie Railroad. The successful burning of bituminous coal in these engines is, of course, obtained by exercising some judgment in their manipulation, and their chief advantages are their very large grate surface and combustion chamber, and the ready facilities for admitting air over the top of the fire, permitting it to combine with the smoke as it arises from the surface of the fire, and to consume it in the combustion chamber before it passes out through the stack. We have built engines of this sort for burning the very poorest quality of bituminous coal, or bituminous slack refuse from the mines, having from 35 to

40 per cent. of ash in it, and the engines are giving the greatest satisfaction.

I beg to say, in concluding, that, judging from the experience of the preceding speaker, we are to believe that the consumption of petroleum as fuel under steam boilers is attended with considerable smoke until the furnaces, which are firebrick, have become incandescent. While this is, no doubt, true of the cases cited by the speaker, we do not find it the case in locomotives, as we have built very large numbers of locomotives for burning petroleum, and we find that we never have any annoyance from smoke; that if the fireman is at all careful and attends to his business, the locomotive can be operated under all conditions and at all times without making any smoke or dirt whatever. This experience is not obtained merely by my own experiments between Baltimore and Jersey City, but is the experience of all our engineers returning from Russia, for which country we have built large numbers of oil-burning engines, and where oil is the fuel for generating steam in almost all cases; and its use is absolutely smokeless.

I neglected to say that for culinary purposes, or domestic use, the bituminous coal could be coked at the mines and used in that shape if it becomes necessary to avoid the smoke from this source. Railroad lines running into Philadelphia have resorted to the use of coke for fuel for their best trains to avoid the smoke due to the use of bituminous coal, and I wish to say that it is perfectly practicable to use coke as fuel in all of the various types of bituminous-burning engines as constructed at the present time.

MR. JAMES CHRISTIE:—It may serve to demonstrate how slowly permanent progress is made, if we reflect on the fact that the subject under discussion this evening has been actively agitated for over a century; for it is over one hundred years since James Watt burnt bituminous coal, without smoke, by means of his dead plate or retort-mouth in front of a fire-grate, and since Benjamin Franklin exhibited his revolving or barrel grate, as just described to us. Some may further wonder what interest Philadelphia has in the

subject, situated as she is so close to the anthracite fields. But as we find that bituminous coal is now delivered here at a lower price than anthracite of buckwheat size, and that the calorific power of the former substantially exceeds the latter, we are forced to the conclusion that the subject of smoke prevention is now at hand.

It has long been well known that if the first products evolved from coal were passed through a mass of incandescent fuel, a smokeless flame was readily obtained. Consequently, the annals of invention are replete with devices to accomplish combustion in this way.

The coal has been pushed up from beneath—keeping the incandescent mass on top—constituting the so-called under-fed methods; the coal has been heaped on top, but the draft acting downwards, forming the down-draft systems, and the coal has been pushed in horizontally and the incandescent mass kept in front of it. This latter is the usual system with the mechanical stokers of to-day, and excellent results are obtained for steam boilers and similar purposes. The down-draft system also gives good results when properly applied, but I know of none of the under-fed systems which have endured.

I had the opportunity, thirty years ago, to experiment on a very ingenious adaptation of the under-fed system, but soon found that its inherent defect was a tendency to push the ashes and incombustible constituents of the fuel into the burning mass, and, unless the fuel was exceptionally pure, the fire was rapidly fouled.

In many furnaces wherein metallurgical and similar operations are conducted, it is essential that no uncombined oxygen shall pass through the furnace; consequently, there will be some smoke emitted even when regenerative furnaces and producer gas are employed. Also, none of the smoke-preventing methods proposed have been thoroughly effective in the case of domestic stoves and grates, and the smoke emitted from these is large in the aggregate in districts where bituminous coal is the principal fuel.

Experience has shown it to be a very difficult subject

to control by legislation. More can be done by sanitary officials whose action is suggestive and advisory rather than harsh and repressive.

MR. MAX LIVINGSTONE:—So much has been presented this evening about the subject under discussion, that I can only add, referring especially to petroleum, that while it is, as Mr. Outerbridge has said, the ideal fuel, we can scarcely look for its general introduction, as the present production would fall considerably short of the demand.

But it is not with the "ideal fuel" that we have to deal this evening. Our consideration has to be given to fuel responsible for the smoke nuisance, and for its abatement we have to look to the, I might say, classical ground of England, where, by force of circumstances, every effort has to be used to suppress the annoyance. The late hour, however, does not permit a discussion in detail this evening.

[Owing to the lateness of the hour, and as a number of intending participants had been unable to express their views on the subject, it was decided to continue the discussion at the next stated meeting, Wednesday, May 19, 1897.—W.]

THE TIN PLATE INDUSTRY IN THE UNITED STATES.*

BY COLONEL IRA AYER,
Special Agent U. S. Treasury Department.

The tin plate industry dates its birth, and the conditions which resulted in its steady and rapid growth and permanent establishment in the United States, from the passage of the Tariff Act of October 1, 1890, commonly known and referred to as the McKinley Law.

Prior to that time, viz.: in 1873, a few plates were made by a firm at Wellsville, O., and by one at Leechburg, Pa., but both enterprises proving unprofitable, in 1875 they were discontinued. About that time works were built and opera-

* A lecture delivered before the Franklin Institute, March 5, 1897.

tions begun at Demmler, near Pittsburgh, Pa. The ruling price of tin plates was then so high as to afford a large margin of profit to Welsh manufacturers, but as they practically had no competition they fixed their own price to the American consumer. If these prices had continued, domestic plates would probably have been able to hold their own against the competition of foreign plates, but such was not the case. As soon as it became evident to Welsh manufacturers that American firms were liable to become formidable competitors, they began to reduce their prices until, in 1879, the price was so low that the Demmler works closed, it being impossible, under the existing conditions, to continue the manufacture without loss, and were not reopened for the manufacture of tin plates until the passage of the McKinley Law in 1890, a period having elapsed of from eleven to twelve years.

Under the provisions of the McKinley Law a duty was imposed on tin and terne plates of 2·2 cents per pound, a duty which it was believed would afford ample protection to American manufacturers, and would result in the establishment of the industry in this country.

That such was the belief and the intention of Congress will be apparent by a brief consideration of the provisions of paragraph 143 of the Act, which required, in substance, that during one of the six fiscal years beginning July 1, 1891, and ending June 30, 1897, the total production of tin and terne plates in the United States, weighing lighter than 63 pounds per 100 square feet, should, as a condition of the continuance of the duty of 2·2 cents per pound as provided, equal one-third the amount of such plates imported and entered for consumption in any one of the said fiscal years; otherwise, on and after October 1, 1897, all such plates should be admitted free of duty.

In the same connection it was provided that the amount of such plates manufactured into articles exported, and upon which a drawback of the duties should be paid, should not be included in ascertaining the amount of such importations.

It was further provided that the amount or weight of

sheet iron or sheet steel manufactured in the United States, and applied or wrought in the manufacture of articles or wares tinned or terne-plated in the United States, with weight allowance as sold to manufacturers or others, should be considered as tin and terne plates produced in the United States within the meaning of the Act.

The exact bearing of these provisions will, perhaps, be more clear by a few words of explanation.

First, then, tin plates are sheets of iron or steel coated with tin. They are used in making many kinds of domestic utensils, also in the manufacture of cans for the preservation of fruits and vegetables, and for many other purposes, which will be readily recalled.

Terne plates are sheets of iron or steel coated with an alloy of tin and lead, the proportion of tin being usually from 10 per cent. to 30 per cent. Terne plates are generally used for roofing purposes, and are hence sometimes called roofing plates.

Plates weighing lighter than 63 pounds per 100 square feet are what are known in commerce as I C plates and I X plates, which are so thin, or of so light a make, as to be suitable for manufacture into tin cans. The provision removing the duty on this class of plates on and after October 1, 1897, in case the prescribed conditions of manufacture had not been met by American manufacturers, was intended particularly as a concession to the canning industries, whose business would presumably be interfered with for a time, by the increased price of tin plates, growing out of the increased rate of duty, the increase being 1·2 cents per pound more than was provided by the previous tariff.

In view of the provisions of law cited, and which I have endeavored to make clear, it became necessary for the Government to procure correct statistics:

(1) Of the aggregate production in the United States of tin and terne plates, weighing lighter than 63 pounds per 100 square feet, during each of the six fiscal years named in the act.

(2) The amount or weight of sheet iron or sheet steel manufactured in the United States, and applied or wrought

in the manufacture of articles or wares, tinned or terne-plated in the United States, with weight allowance as sold to manufacturers or others, for each of the said years.

(3) The total importations and exportations with benefit of drawback of all such plates during each of the fiscal years covering the same period.

Under a ruling of the department, the coating of metal sheets, or "black plates," as they are called, whether of American or foreign manufacture, with a tin or terne coating, constituted a manufacture of American tin plates within the meaning of the law.

It has been held, without question, that the tin used for coating the plates may be either of American or foreign production. On the other hand, with respect to the sheet iron or steel, applied or wrought in the manufacture of articles or wares, tinned or terne-plated in the United States, the department rigidly held that they must be of American production, as the law explicity refers to "sheet iron or sheet steel manufactured in the United States." It was not understood that the limitation relative to minimum weight applied to these last-named manufactures, the last proviso of paragraph 143 being silent upon that point.

It was in October, 1891, some four months after the tin plate provision of the law went into effect, that I received my instructions from the Treasury Department to collect and formulate these statistics, and put them in the form of a permanent record at Washington for the information of the administrative officers of the Government. At that time there was a strong feeling against many of the provisions of the McKinley law, and against the tin plate provision the feeling was especially strong.

It was persistently denied that tin plates were being made in this country, the industry was belittled and American manufacturers were held up to scorn and ridicule. The importing interests, represented largely by the agents of foreign manufacturers, were exceedingly hostile, and, owing largely to their representations, there was a widespread belief that tin plates could not be made in the United States. Even friends of the industry shared this belief, or at least were

the subjects of doubt and misgivings. Probably nothing of the kind was ever so little understood, or so much attracted public attention and awakened so deep an interest. Many were ignorant as to what tin plates and terne plates really were. The question was not infrequently asked if we "were producing any *tin* in this country," the presumption being that unless we had tin mines and could mine tin successfully, the industry must prove a failure. It was not generally understood that much of the tin used by British manufacturers for coating their plates was obtained from the East Indies and other countries, and that those sources of supply were open to us as well as to them.

Under these circumstances, one of the first thoughts that occurred to me on receipt of my instructions was that, amidst all the contention and misapprehension upon the subject, the country would at last be placed in possession of the facts.

The necessary books were prepared for the use of manufacturers, in which to keep a daily record of their production, and it was arranged that each should make a sworn return of his production at the end of each quarter. Blanks were prepared and furnished to manufacturers for this purpose, and while the law was in force, not a single return was accepted that was not in proper form and duly sworn to. These blanks were made to show, separately, the production of tin and terne plates, both of the lighter and the heavier class, that is to say, lighter than 63 pounds per 100 square feet, and 63 pounds per 100 square feet and heavier. They were also made to show the quantity of plates made from American-rolled black plates, and the quantity from foreign plates.

Circular instructions were issued to manufacturers by the department, setting forth what would be required of them under the law, one set of instructions and blanks being for the guidance and use of manufacturers of commercial tin and terne plates, and another for the guidance and use of stamping or other manufacturing companies, using American sheet iron or steel for stamping or making into articles and wares, that were tinned or terne-plated after being formed.

Collectors of customs at the importing and exporting ports of the country were directed by circular instructions to make quarterly reports of importations and of exportations, with benefit of drawback, of tin and terne plates of the lighter and heavier weights separately, and my reports were made in accordance with the figures so obtained. The blanks called for reports of the production, importation and exportation of the class of plates weighing *heavier* than 63 pounds per 100 square feet, not because it was strictly necessary under the law, but as a check which it was considered would result from the more clear analysis of data thereby secured, and for the more complete information of the Government.

All of these plans had the concurrence of the Board of Managers of the American Tinned Plate Manufacturers' Association, with whom I had previously conferred at Pittsburgh, and who fully recognized the importance of the utmost care in the preparation of the statistics.

The results of the Congressional election of 1891 were regarded by many as a serious misfortune to the new tin plate industry. This was particularly felt to be so by manufacturers, who had plans for enlarging their operations, and who found it desirable to enlist the interests of capital. It was feared that early steps would be taken to repeal the law, and perhaps remove the duty altogether on tin plate and the protection to the industry which it afforded. This was, in fact, done by the House of Representatives at its first session by the passage of what was known as the Mills Bill, which provided for a reduction of the duty on tin plates from 2·2 cents to 1 cent per pound, from October 1, 1892, and made them free of duty on and after October 1, 1894, but the Republican Senate stood as a barrier to that policy.

Despite all opposition, and all causes of discouragement, the American manufacturer, with an abiding faith in himself, with a patience that has seldom been excelled, and with unfaltering courage, stood calmly at his post and worked out the difficult problems that confronted him.

My first report to the department, showing the actual

state of the industry, was dated April 26, 1892. Congress was then in session, and debate was rife between the friends of the law and its opponents. The report showed that during the quarter ended September 30, 1891, the first quarter of the industry's existence, five firms produced, of tin and terne plates, an aggregate of 826,922 pounds. The pioneer manufacturers were Marshall Brothers & Co., and the N. & G. Taylor Company, of your city, the Pittsburgh Electro-Plating Company, of Apollo, Pa., the United States Iron and Tin Plate Manufacturing Company, of Demmler, Pa., and the St. Louis Stamping Company, of St. Louis, Mo. The output for the first quarter was less than 1,000,000 pounds, but it was a beginning.

	Pounds.
The total of tin plates was	152,489
The total of terne plates was	674,433

During the quarter ended December 31, 1891, eleven manufacturing firms produced of

	Pounds.
Tin plates	215,911
Terne plates	1,193,910
Total	1,409,821

During the quarter ended March 31, 1892, nineteen manufacturing firms produced of

	Pounds.
Tin plates	1,099,656
Terne plates	2,109,569
Total	3,209,225

The total product for the nine months ended March 31, 1892, was:

	Pounds.
Tin plates	1,468,056
Terne plates	3,977,912
Total	5,445,968

From these figures you will see that during the three quarters named, the number of manufacturers and the production were practically doubled with each quarter. I may here add that during the fourth quarter of that fiscal year,

ended June 30, 1892, twenty-six firms were manufacturing commercial tin and terne plates, and their output for the quarter was:

	Pounds.
Tin plates	3,071,534
Terne plates	5,129,217
Total	8,200,751

The total production for the first year of the industry was:

	Pounds.
Tin plates	4,539,590
Terne plates	9,107,129
Total	13,646,719

of which about 90 per cent. were of the lighter class named in the law.

The first report showed that during the fiscal years ended June 30, 1888, 1889 and 1890, the average importations of tin plates into the United States had been about 678,000,000 pounds per annum, and the average exportations, with benefit of drawback, were estimated at 150,000,000 pounds per annum. The importations during the fiscal year ended June 30, 1891, were excessive in order to escape the higher duty beginning with July 1st of that year, and amounted to 1,058,000,000 pounds.

It naturally followed that the importations during the fiscal year ended June 30, 1892, would be correspondingly light, and from all the data at hand, it was estimated that the net importations of that year would be 300,000,000 pounds.

The case then stood substantially as follows: that it would be incumbent upon domestic manufacturers, under what was termed the one-third provision, and in order to insure the indefinite continuance of the duty of 2·2 cents per pound, under the law as it then stood, to produce during one of the six fiscal years from July 1, 1891, to June 30, 1897, 100,000,000 pounds of tin and terne plates, weighing lighter than 63 pounds per 100 square feet. Upon no reasonable hypothesis could the one-third net importations, to be

equalled by American producers, exceed 100,000,000 pounds; it was shown that it was likely to fall considerably short of that amount.

The final returns showed this amount to be, in round numbers, 79,000,000 pounds for that fiscal year, and this amount was equalled by manufacturers, under the decision which classed foreign-made black plates as an American product, if coated in this country, during the fiscal year ended June 30, 1893, the third year of the life of the industry.

Not only was it equalled, but there was an excess of more than 14,000,000 pounds of commercial tin and terne plates, no account being taken of American steel, stamped or made into forms, tinned or terne-plated, which was about 9,000,000 pounds. The total excess, therefore, in that year was about 23,000,000 pounds.

While it was now conceded by some of the opponents of the law that tin plates may have been made in a few small "American *dipperies*," as they chose to term them, by the coating of foreign-made plates, it was strongly denied that "black plates" were being made, or could be made, and hence it was argued that the industry was practically a failure. If this had been true, the conclusion would have had much force; but, happily for the credit of American manufacturers, and for the promise of substantial success for the new industry, the facts were all upon the other side. Before proceeding further, it seems desirable to explain here, briefly, what is meant by the term "black plates."

These are plates of sheet iron or steel which are rolled, usually in packs of eight thicknesses. The thickness is generally from 26 to 29 gauge, weights which are commonly used in making the various articles of tinware for domestic purposes. After rolling and separating the sheets in the packs, they are given a special treatment, as a necessary preparation for covering them with a tin or terne coating.

This treatment consists, first, in placing the plates in a moderately strong, heated aqueous solution of sulphuric acid, by which means the scale produced in the process of hot rolling is removed. This first acid solution is known as the "black pickle."

On being taken from the pickle the plates are washed and cleansed in water, and are then ready for the annealing furnace. For this purpose they are placed in iron boxes or "pans," and are closed in with cast or wrought iron covers, the space between the flange of the "pans" and the covers being filled in with sand to exclude the air.

They are now referred to as annealing "pots," and are run into the annealing furnace, where they are subjected to a moderate cherry-red heat for ten or twelve hours, and sometimes more, until they have become thoroughly "soaked," as it is called. After being removed from the furnace, the "pots" must be allowed to cool off before they are opened, otherwise scale would be formed to the injury of the plates.

After cooling, the plates are passed separately through cold rolls, which smooths and, to a certain extent, polishes the surface. This process hardens the plates, and they must again be annealed in order to give them the required toughness and pliability. They are now treated with another acid solution, known in the art as the "white pickle," in order to remove all roughness, and give them a perfectly smooth surface; the surfaces are then cleansed and are placed in boxes of clean water ready for the coating process in the tinning pot or tinning machine.

It is true that the manufacture of a prime quality of black plates requires proper facilities, combined with experience, care and attention; but there is no part of the process of which all the conditions necessary to the most complete success are not clearly understood, and cannot be readily secured. It was believed at that early period of the industry that the manufacture of black plates in this country would be found to be practically commensurate with the demand for the same in the production of commercial tin and terne plates.

As a means of gaining such full information upon the subject as might prove of interest, a circular letter was addressed to manufacturers, and from a large proportion responses were received, a majority of which showed that the work of building and enlargement on substantial lines, as

well as that of actual manufacture, was being successfully and energetically carried forward. These letters were embodied in my first report, and were read with great interest and satisfaction by the friends of the industry, in the debates that were then going on in Congress. I regret that time will not permit my quoting at length from these letters. I can only briefly refer to a few.

Mr. W. C. Cronemeyer, who was at the time, and is now, President of the United States Iron and Tin Plate Manufacturing Company, at Demmler, Pa., already mentioned, and who has been justly recognized as having been influential in urging the necessary measures for the manufacture of tin plates in this country, wrote in part as follows: "This firm started the business of making tin and terne plates in 1874, and continued with but slight interruptions until 1879. They then gave it up altogether, having become convinced that without adequate protection, in harmony with similar rates on the iron industry, the tin plate industry would not prosper." Mr. Cronemeyer submitted many testimonials and original letters, showing the high estimation in which the domestic products were held by American consumers. As illustrating the actual business of the firm about that time he sent me a transcript of two pages, taken from their sales book for April 21 and 22, 1892, showing the sale of 357 boxes to eighteen different firms, in seven different States, extending from Massachusetts to Iowa. Of these, 168 boxes were bright, or tin plates, and all were made from American-rolled sheets.

The St. Louis Stamping Company, as before shown, was one of the first to engage in the new industry. From their letter it appeared that they were then running four sets of hot rolls and four sets of cold rolls in the manufacture of black plates. They had ten tinning stacks in operation, and six building. Further improvements and additions were being made in their rolling mill.

The firm of Marshall Bros. & Co., of this city, had been recently reconstructing their rolling mills for the manufacture of black plates, and had erected a tinning plant complete, all of which, as shown by their letter, were in successful operation.

The Blairsville Rolling Mill and Tin Plate Company, of Blairsville, Pa., were nearly ready to commence operations. Their letter gave a concise description of their plant, which was built in a very substantial manner, complete in all respects for the manufacture of black plates, as well as of tin and terne plates.

The letter of the New Castle Steel and Tin Plate Company, of New Castle, Pa., now one of the largest and most successful tin plate manufactories in this country, or in the world, showed that they received their charter February 29, 1892, and had already let their contracts for the erection of a complete plant, including a rolling mill to roll their sheets for tinning from Bessemer steel billets.

Their buildings were to be made entirely of iron, and their contracts called for the very best machinery that could be made in the way of mills and tinning machines, to turn out a weekly production of 2,500 boxes of roofing and bright plates. What they further said reflected the general sentiment of manufacturers as expressed in their letters.

They stated: "We are investing our money in a plant with the expectation of being able to pay our workmen American prices. This can be done under the present tariff. The agitation in Congress for reducing the present duty on tin plates has done more to retard the development of the industry than all other causes."

The N. & G. Taylor Company, of this city, wrote that they were doing all in their power to hurry the completion of their works, which they expected to be in operation by July 1st. They were to put in twenty-four tinning stacks, and have to-day one of the largest and best-equipped coating factories in the country. While they do not roll their own black plates, they use largely those of American manufacture.

The Record Manufacturing Company, of Conneaut, O., although not large manufacturers, explained in detail and in an interesting manner the difficulties which they had encountered in being limited to the foreign supply, and the advantages they had already experienced in their new manufactures, they themselves being large consumers of

plates. The firm also gave testimony to the superior quality of American black plates, although their original expectation appears to have been to use only foreign-made plates.

The company said that, judging from their past month's experience, they would regret exceedingly to go back to foreign plates for supplies for their factory, for quite a number of reasons, one being that a superior quality of metal is used in this country for the manufacture of black plates.

They stated that during the last month they had used from their own plant upwards of 680 boxes, and had not had a single sheet crack under their dies, which was something they could never say of the highest grade of foreign plates.

They had, besides, sold from 200 to 300 boxes in sample lots, one, two and three boxes in a place, and had had the highest commendation from those who had received them, both as to quality of metal and coating.

During the last month, they stated they had received from American mills about 200,000 pounds of black plates, and in the following month they expected to utilize more than double that quantity.

The letter added that, at the time the McKinley Bill was passed, they thought that it was a great leap in the dark, and that they wrote their representatives in Congress, Representative Taylor and Senator Sherman, upon the subject. They at that time believed, however, that if Congress would let the law remain as it was, in a short time the country would see as cheap and cheaper tin plates than it ever saw before.

A number of weighty reasons other than those mentioned were presented by this firm why they would regret to go back to the use of foreign-made plates, reasons which were of general application, and hence of general interest to all tin plate consumers.

The Norton Brothers, of Chicago, manufacturers of tin cans on an immense scale, wrote that they had already expended more than $100,000 in an effort to perfect a process for the direct rolling of fluid steel into sheets from the open hearth furnace, without first casting an ingot, as was the common practice, and at the time they had strong hopes

of success, hopes which have not, I believe, been as yet realized.

They further stated that during the year then past, they had perfected an entirely new system of tinning the black sheets by what is known as the palm-oil process, which would greatly improve the quality of the tin plates over those which were then furnished by the Welsh makers of the cheaper grades for canning purposes. This, they stated, was the quality of tin plates which was their specialty, and which they used in their business more extensively than any other house in the United States.

They explained that nearly all the plates of this character made in Wales at that time were being tinned by the use of what is termed "flux," that is, a solution of diluted muriatic acid. The cleaned and pickled plates are immersed in this solution before being dipped into the tinning pots. The reason for the general adoption of this process in Wales is that tin plates thus made are more rapidly tinned than where the old hand-made, palm-oil process is used, in which the sheets are thrown into vats of heated palm-oil, and allowed to soak, thus evaporating the water in the plates, as a preparatory step to tinning.

The firm stated that they had had great difficulty in the last few years in the use of these acid-coated plates, as the acid in time causes the steel to rust out underneath the tin coating, and pin-holes appear in the plates sometimes after the goods are made up, thereby causing great loss to the user.

"We determined," the letter continues, "to overcome this difficulty before engaging extensively in the manufacture, and are happy to state that we have devised a process by which this is accomplished, and whereby we are able to produce a perfectly coated tin plate by as rapid working machinery as is used in the acid process, and entirely with the use of a palm-oil or grease flux, instead of the objectionable acid flux."

The firm stated that they were using from 25,000,000 to 30,000,000 pounds of tin plates yearly in their business, and they are now coating that amount by their own process as

before described in their large coating factories at Maywood, near Chicago, and at Baltimore, Md., using solely American-rolled black plates.

This must conclude our hasty glance at these letters. Less than five years have since transpired, but their perusal throws a strong light on the situation at that time, and enhances our respect and sympathy for the early pioneers in American tin plate manufactures.

A brief survey of the then existing conditions may not prove uninteresting, and I can perhaps do no better than to give the conclusions of my report, which I will present as if read of the date they were written. In presenting my conclusions I said:

From my investigations it would appear:

(1) That tin and terne plates are being made in this country by American manufacturers in commercial quantities, and are being offered and purchased in quantities by American consumers throughout a large part of the United States.

(2) These domestic plates have been extensively tested by American consumers, and have given universal satisfaction, the testimony going to show that they are equal, if not superior, to foreign-made plates of similar kinds. The features of excellence comprise toughness and pliability of the black plates or metal sheets, and also perfection of coating.

(3) The development of the new industry has largely stimulated the manufacture of American black plates. It has been shown that the number of companies or firms whose names are found in the appended list, and who are making or are preparing to make black plates, is seventeen. Besides these, at least five other firms, whose names have been given, are known to be engaged in the manufacture. I am advised that manufacturers of black plates are now keeping tin plate manufacturers regularly informed of their increased facilities for filling orders.

(4) Manufacturers of machinery have already turned their attention to the special forms of machinery required in the production of tin and terne plates. This is the case with such firms at Pittsburgh, Pa., at Youngstown, Ohio, and at other points.

(5) The industry has developed with satisfactory and, in view of attendant difficulties, with surprising rapidity, and has passed the experimental stage. Capital, at first cautious, is now being freely invested in this branch of manufactures.

(6) A comparison of the relative increase in production of tin and terne plates for the past three quarters serves to illustrate the correctness of the conclusions above reached.

The chief ultimate object to be attained was the manufacture of tin plates, the reason being that the consumption of tin plates in this country hitherto has been greatly in excess of that of terne plates. The importation of the former, as shown by the returns for the first six months of the present fiscal year, was about 93 per cent. of the entire importations.

By comparison made below it will be seen that the ratio of increase in the production of terne plates during the last quarter was greatly diminished, while that of tin plates was largely augmented. While the methods of manufacture are the same, terne plates are less difficult to make than tin plates, and as a consequence, manufacturers generally began their experimental operations with the former.

During the first quarter of the fiscal year, the production of terne plates, as compared with that of tin plates, was in the ratio of 4 to 1. During the next quarter, with more than double the number of manufacturers in the field, the ratio was more than 5 to 1. During the third quarter, ending March 31, 1892, with the number of manufacturers again practically doubled over that of the previous quarter, it was largely reduced, the ratio for that quarter being considerably less than 2 to 1.

During the same quarter the increased production of terne plates over that of the previous quarter was less than 60 per cent., while the increased production of tin plates over that of the previous quarter was in excess of 500 per cent.

These figures go to show that even now the relative production of tin plates and terne plates in this country does not depend upon the ability of manufacturers to produce the former, but, as is the case with most manufactures,

upon the law of demand and supply. The same remark applies with respect to the relative quantities of plates made of the lighter and heavier weights described in the law. An inspection of the exhibits will show that of the entire production during the first quarter of the fiscal year, only about 70 per cent. consisted of the class of plates weighing lighter than 63 pounds per 100 square feet. During the second quarter the production of the lighter class, as compared with the whole, was about 87 per cent., and during the third quarter, ended March 31, 1892, it was about 91 per cent. Should this increase continue in the same ratio until the beginning of the next fiscal year, the percentages of the lighter class of plates imported and produced in this country would practically correspond.

(7) The present quarter will, in all probability, witness the production of as much tin and terne plate in this country as did the previous three quarters taken together. This means 10,000,000 pounds of tin and terne plates of American production during the year, to take the place of foreign-made plates. In the lowest estimate hereinbefore made of 680,000,000 pounds of imported tin and terne plates to supply the wants of the country during the present fiscal year, no account was taken of the home production for the year. In point of fact, however, the presence and consumption of 10,000,000 pounds of domestic plates would tend to confirm that estimate.

(8) The future development of the canning industries of the country, and the embarrassments that the industries have struggled against on account of their dependence upon a foreign country for their supply of tin plate, afford a strong reason for the establishment of tin plate manufactures in this country. This achievement means, on the basis of recent yearly importations, the expenditure in the United States, instead of foreign countries, of over $20,000,000 in gold, or its equivalent.

(9) The certainty of increased production, together with the improvements that have already been made and that are in progress, to cheapen the cost of manufacture, and at the same time better the quality of the plates, are most encouraging with respect to reduced prices.

(10) The letters from manufacturers, which are herewith submitted, show that they are meeting with encouraging success and that they deprecate any change in the present law.

We have seen that during the fiscal year ended June 30, 1892, the first year of the industry, the production of commercial tin and terne plates was 13,646,719 pounds. Of this amount, over 9,000,000 pounds, or more than 68 per cent., were made from American black plates. Twenty-six firms were engaged in the work of actual production during the quarter ended June 30, 1892.

Passing rapidly over the work of the four following years, the reports show that during the quarter ended June 30, 1893, thirty-five firms were engaged in actual production, and during that year about 100,000,000 pounds of commercial tin and terne plates were manufactured. During the quarter ended June 30, 1894, forty firms were producing, and during that year the production was more than 139,000,000 pounds.

On the 28th of August, 1894, the enactment known as the Wilson Bill became law. The duty on tin and terne plates was reduced thereby from 2·2 to 1·2 cents per pound. The duty on black plate, which, under the McKinley law, had been 1·65 cents per pound, and which many had regarded as too low, was placed by the Wilson Bill at 1·225 cents per pound. The purpose of this was to leave the duty on black plates in harmony with that on other products in the iron industry. The duty was reduced on steel billets, which may be regarded as the raw material from which black plates are rolled, and from this and other causes the market price of billets became unprecedentedly low. The duty of 4 cents per pound, which had been placed upon block tin by the McKinley law to encourage the development of tin mining in this country, was removed, and block or pig tin, which forms the coating of tin plates, was admitted free of duty.

This worked no hardship to those interested in tin mining, for during the three previous years it had been demonstrated that, under existing conditions, tin mines could not

be profitably worked in the United States. Considerable outlays had been made on the Temescal mine in California, and the Harney Peak mines in North Dakota, with results, at times, more or less promising, but the work on both had been abandoned before the passage of the Wilson Bill.

As before indicated, it had become apparent that the United States must look for its tin to the East Indies and other sources of supply, as has been for years past, to a greater or less extent, the case with Welsh manufacturers.

Besides the conditions mentioned, American manufacturers felt that they could now rely upon the duty remaining permanently as fixed by the Wilson Bill. They had mastered the difficulties of manufacture, and were no longer, as they had been at first, almost entirely dependent upon foreign labor. Domestic tin plates had now secured a high standing with American consumers, and, other things being equal, their patriotic impulses led to a demand for the home product.

The general business conditions, growing out of depressed wages and low prices for all kinds of raw material, were favorable to the erection of new plants at a minimum of cost. From all of these causes the growth of the industry during the fiscal year ended June 30, 1895, the fourth year of its existence, was well-nigh marvellous.

The special provisions of the McKinley law, which I have explained, and which made the statistics a necessity, had been abrogated, but the public interest remained so great in the subject, that the department directed a continuance of the work with yearly reports.

My report for the fiscal year ended June 30, 1895, showed that the production in the United States of commercial tin and terne plates was about 194,000,000 pounds, as against 139,000,000 during the previous fiscal year. Forty-eight firms were producing during the quarter ended June 30, 1895, as against forty during the corresponding quarter of the previous fiscal year.

During this fiscal year, seven firms (coating factories) permanently discontinued production, and their names were accordingly dropped from the list of manufacturers given

with my report. Twenty-seven new firms engaged in the active business of building, or of building and production during the year, of which seventeen were making or preparing to make black plates. Twenty-eight rolling mills were producing black plates during the quarter ended June 30, 1895, against twenty that were producing during the quarter ended June 30, 1894.

My last report (that for the fiscal year ended June 30, 1896), which was the fifth year of the industry, showed that the production of commercial tin and terne plates in the United States during that year amounted to more than 307,000,000 pounds, against about 194,000,000 pounds during the previous fiscal year, an increase of more than 58 per cent. Of the entire production, about 265,000,000 pounds, or more than 86 per cent., belonged to the class of plates weighing lighter than 63 pounds per 100 square feet, and of this lighter class, 182,000,000 pounds consisted of tin plates.

The quantity of American sheet iron and steel made by stamping and other manufacturing firms into articles and wares, which were afterwards tinned or terne-plated, was 10,586,110 pounds, showing a consumption of American sheet iron and steel in this class of manufactures of more than 4,000,000 pounds in excess of that for the year immediately preceding, and of nearly 4,000,000 pounds in excess of the average for the four previous years.

The production of black plates in the United States dur. ing the year was 334,000,000 pounds, that for the previous year having been 185,000,000, showing an increased production of 149,000,000 pounds, or about 80 per cent. more than that of the previous year.

Thirty-six rolling mills were producing black plates during the fiscal year ended June 30, 1896, an increase of seven over the previous fiscal year.

The proportion of American rolled sheets used during the year, compared with the entire production of commercial tin and terne plates, was 98½ per cent., against about 83 per cent. used during the previous fiscal year.

During the year six firms (coating factories) permanently discontinued production, and three new firms engaged in

the active business of building, of which two were preparing to make black plates.

The total number of firms engaged in tin and terne plate manufactures June 30, 1896, was 74, of which there were making or preparing to make black plates, 43. The number of firms making black plates only was 7. The total number of hot mills (for rolling black plates) completed June 30, 1896, was 180; the number building was 8; completed and in process of construction, 188.

The number of tinning machines and sets completed June 30, 1896, was 430; the number building was 30; completed and in process of construction, 460.

Sixteen stamping or other manufacturing companies used American sheet iron or steel in the production of articles and wares tinned or terne-plated.

In 1893 the department rendered a decision to the effect that only tin and terne plates made from black plates rolled in the United States could be considered as American tin plates within the meaning of the law. It will be of interest to find whether, under this ruling of the department, American manufacturers have yet complied with what may be termed the one-third requirement, which, by implication, would have continued the duty of 2·2 cents per pound, had the law remained unchanged. We take the figures as we find them for the fiscal year ended June 30, 1896:

	Pounds.
The importations of tin and terne plates in that year, of the class weighing lighter than 63 pounds per 100 square feet, were, in round numbers	371,000,000
The exportations of the same class of plates with benefit of drawback, during the same period, were . . .	135,000,000
Making thereby the net importations	236,000,000
One-third of which is, say	79,000,000
The aggregate of commercial tin and terne plates of the lighter class, produced in the United States during the same period wholly from American rolled sheets was, in round numbers	265,000,000

or more than $3\frac{1}{3}$ times the quantity that would have been necessary to meet the one-third requirement under the McKinley law, had it remained in force.

The production, from American-rolled sheets, of tin plates alone, of the class weighing lighter than 63 pounds per 100 square feet, during the fiscal year ended June 30, 1896, was about 182,000,000 pounds, or more than 2¼ times the quantity necessary to have met the one-third requirement of the McKinley law.

If these statistics are obtained for the present fiscal year, which is the last of the six fiscal years named in the McKinley law (and it is not improbable that they will be), they promise to exhibit even more striking results than those which we have just been considering.

[The lecture was fully illustrated, at its close, with the aid of a series of lantern slides. Among other interesting views thus shown was the accompanying condensed statistical exhibit of the development of the tin plate industry, since the passage of the McKinley Tariff Act of October 1, 1890.]

SUMMARY STATEMENT OF PRODUCTION OF TIN AND TERNE PLATES IN THE UNITED STATES FOR THE FISCAL YEARS 1892, 1893, 1894, 1895 AND 1896, RESPECTIVELY.

Period from—		Tin Plates.			Terne Plates.			Tin and Terne Plates.	Amount Made From—		Total.
		Lighter than 63 Pounds per 100 Square Feet.	63 Pounds per 100 Square Feet and Heavier.	Total.	Lighter than 63 Pounds per 100 Square Feet.	63 Pounds per 100 Square Feet and Heavier.	Total.	Aggregate Production.	American Black Plates.	Foreign Black Plates.	
		Lbs. Net.	*Lbs. Net.*	*Lbs. Net.*	*Lbs. Net.*	*Lbs. Net.*	*Lbs. Net*	*Lbs. Net.*	*Lbs. Net.*	*Lbs. Net.*	*Lbs. Net.*
July 1, 1891, to Sept. 30, 1891,	First fiscal year under law of Oct. 1, 1890.	134,869	17,620	152,489	442,552	231,881	674,433	826,922	785,547	41,375	826,922
Oct. 1, 1891, to Dec. 31, 1891,		181,501	34,410	215,911	1,046,879	147,031	1,193,910	1,409,821	1,200,661	209,160	1,409 821
Jan. 1, 1892, to Mar. 31, 1892,		1,018,698	80,958	1.099 656	1,907,869	201,700	2,109,569	3,209,225	2,132,082	1,077,143	3,209 225
Apr. 1, 1892, to June 30, 1892,		2,796,941	274.593	3,071,534	4.795,236	333,981	5,129,217	8,200,751	5,178,263	3,022,488	8,200,751
Total		4,132,009	407,581	4,539 590	8,192,536	914,593	9,107,129	13,646 719	9,296,553	4.350,166	13,646,719
July 1, 1892, to Sept. 30, 1892,	Second fiscal year under law of Oct. 1, 1890.	3.337.036	274,331	3,611,367	6 875,958	465.400	7,341.358	10,952,725	5,920,082	5,032,643	10,952,725
Oct. 1, 1892, to Dec. 31, 1892,		5,274.434	864.305	6,138,739	12,684,646	933.106	13,617,752	19,756,491	8,043,449	11,713,042	19.756,491
Jan. 1, 1893, to Mar. 31, 1893,		14 333.875	910.699	15.244,574	13,803.461	518,364	14.321,825	29,566,399	11,371,968	18,194,431	29,566.399
Apr. 1, 1893, to June 30, 1893,		19 425 336	1,323,091	20,748,427	18,115.741	679,419	18,795,160	39,543,587	18,264,225	21,279 362	39,543.587
Total		42,370,681	3.372,426	45,743,107	51,479,806	2.596,289	54,076,095	99,819,202	43,599,724	56,219,478	99,819,202
July 1, 1893, to Sept. 30, 1893,	Third fiscal year under law of Oct. 1, 1890.	13,158,982	702,181	13,861,163	12,807,230	477,087	13,284,317	27,145,480	8,794,027	18,351,453	27,145,480
Oct. 1, 1893, to Dec. 31, 1893,		14.048.471	633,574	14 682,045	12,252,823	416.373	12,669,196	27,351,241	15,907,669	11,443,572	27,351,241
Jan. 1, 1894, to Mar. 31, 1894,		24,815 641	1,497,920	26.313,561	11,486.747	460,103	11,946,850	38,260,411	27,765,162	10,495,249	38,260,411
Apr. 1, 1894, to June 30, 1894,		25,397,731	1,355,265	26,752,996	19,046,617	666,722	19,713 339	46,466.335	33,501,344	12,964,991	46,466,335
Total		77 420,825	4,188,940	81,609,765	55,593 417	2,020,285	57.613.702	139,223,467	85 968,202	53,255,365	139,223,467
July 1, 1894, to Sept. 30, 1894,	First fiscal year under law of Aug. 28, 1894.	27,267,025	2,918,659	30,185,684	15,932,495	2,227 454	18,159,949	48,345,633	33.506,175	14,839,458	48,345,633
Oct. 1, 1894, to Dec. 31, 1894,		15,065.370	3,905,796	18,971,166	12,647.045	1,642,819	14,299,864	33.271,030	24,891,802	8,376,228	33.271,030
Jan. 1, 1895, to Mar. 31, 1895,		22.938,252	5 361,202	28,299,454	13,683,645	2,628,042	16,311,687	44,611,141	39,156,348	5.454,793	44.611,141
Apr. 1, 1895, to June 30, 1895,		37,985.496	4,886,149	42,871,645	20,671,031	4,030 593	24,701,624	67,573,269	63,019,609	4,553,660	67,573,269
Total		103,256,143	17,071,806	120,327,949	62 934,216	10,538,908	73.473,124	193,801,073	160,576,934	33,224,139	193,801,073
July 1, 1895, to Sept. 30, 1895,	Second fiscal year under law of Aug. 28, 1894.	41 861,816	4 239 198	46,101,044	21,930,412	2,892,873	24,823 285	70,924,329	68,887,553	2,036,776	70,924,329
Oct. 1, 1895, to Dec. 31, 1895,		40 006,81	8,648.953	48,655,764	19,647,699	3,159.193	22,846,892	71,502,656	70,253,017	1,249,639	71,502,656
Jan. 1, 1896 to Mar. 31, 1896,		46,604,697	7,302.709	53,907 406	16,08[illegible]067	2,725.884	18.807,971	72,715,377	72,519 781	195,596	72,715,377
Apr. 1, 1896, to June 30, 1896,		53,572,215	10,352.752	63,924,967	25,174,125	2 987,167	28,161,292	92,086,259	91,341,747	744,512	92,086,259
Total		182,045,569	30,543,612	212,589,181	82,874.323	11,765.117	94.639.410	3[illegible] 7.22[illegible],621	303.002,098	4,226,523	307,228,621

AN ALL-WROUGHT STEEL PULLEY.

BY EDWARD G. BUDD,
Member of the Institute.

The different branches of the industrial world are so dependent on one another that progress in one line is invariably accompanied by, and keeps step with, progress in all the others. When an advance has been made in one branch, it will be found that the improvement is called for by some new demand in some branch which it serves, and has been made possible by an advance in another which has preceded it. Many lines of industry have found progress limited by the strength of the material used.

As the manufacturers of material improve their product, all the industries using that material are aided. This has been noticeable in gun and armor manufacture.

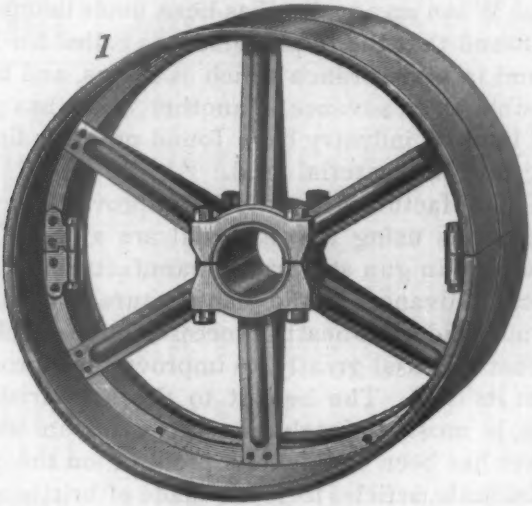
The recent advances in the manufacture of mild steel by the Bessemer and open-hearth processes have enabled those who use that material greatly to improve their product and to cheapen its cost. The benefit to the arts arising from this cause is most noticeable in the cases in which the steel-worker has been enabled to produce, on the practical commercial scale, articles formerly made of brittle cast iron. This has been realized in the case of many familiar articles of hardware and household use.

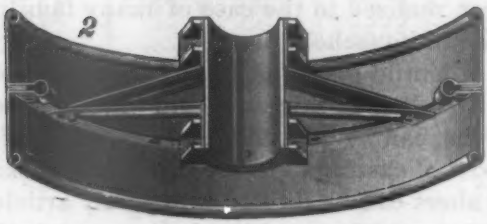
At present a mild grade of steel, of homogeneous structure, carefully rolled to thickness and in long sheets of convenient widths, can be bought at prices, pound for pound, below the cost of castings. In the hands of the skilled steel-worker this sheet can be formed into many articles of complicated structure without taking from its original strength.

Sprocket-chains and other parts of the bicycle, locks, hinges, shelf brackets, and many more simple articles are made cheaply of this strong, ductile material.

It is the purpose of the writer to describe in this communication, an ordinary belt-wheel made entirely of such steel, and representing the highest development of the sheet metal worker's art up to the present day.

Figs. 1 and *2* will give a general idea of the design. The rim is built of four segments. It is divided once transversely and once longitudinally. A means of attachment to the arms is given by the deep flanges which are turned in at the center of the face. The rim edges are stiffened by being turned into a curl, which gives an attractive appearance and avoids scaring the belt in throwing on or off.





The hub is composed of two half cylinders of heavy metal. The hub and rim are connected by four spider pieces—two in each half pulley. As will be seen in *Fig. 2*, there is a spider piece starting at each end of the hub, and which embraces and is fastened to the hub-shell. As the spider arms branch toward the rim, the two opposite arms approach each other, forming a pyramid, and at the

ends they are riveted to the deep flange in the center of the rim.

The arms being of a flat piece, with its edges lying in the direction of rotation, and the two opposite arms being dished towards each other, makes the structure well suited to resist the strains to which it is to be subjected. The lateral stiffness is greatly increased by the deep corrugations which run the length of the arms.

Figs. 3, 4 and *5* will show clearly the method of making one of the spider sections. A flat piece like *Fig. 3*, called

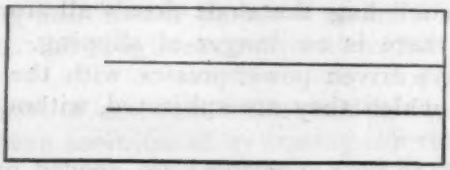


Fig. 3

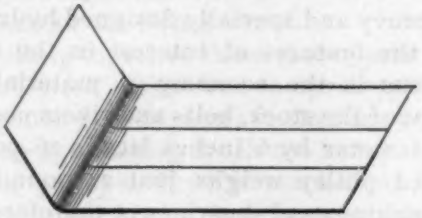


Fig. 4

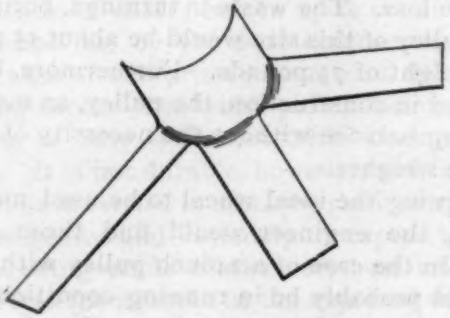


Fig. 5

the hand, is slit as there shown, giving three fingers and a palm. The palm and fingers are then bent at right angles, as in *Fig. 4*.

In another operation the palm is given a convex shape and the fingers take the shape of radial arms, *Fig. 5.*

The ends of the hub are embraced by hub clamps which are attached to each half pulley. The pulley is clamped to the shaft by means of four bolts.

The company building this pulley has taken a step in line with others in advanced practice, by advocating their use in the heaviest service without keys.

The steel hub shell on a steel shaft has a very high coefficient of friction. The clamps are designed so that they make the shell hug the shaft closely all around, and with four bolts there is no danger of slipping. Pulleys thus clamped have driven power-presses, with the severe shock and jar to which they are subjected, without any sign of slipping.

No machine shop operations are needed on this pulley. By carefully designed dies and shears each part is made to exact size. The rim and arms are pressed to their final shapes by heavy and specially designed hydraulic machines.

One of the features of interest in the manufacture of this apparatus is the economy of material. The actual gross weight of the stock, bolts and rivets used in a pulley of 24 inches diameter by 6 inches face is 26 pounds 5 ounces. The finished pulley weighs just 24 pounds. The total waste in punchings and shearings is, therefore, only 2 pounds 5 ounces, and this scrap is salable at a rate which materially reduces the loss. The waste in turnings, borings and gates on a cast pulley of this size would be about 15 pounds with a finished weight of 75 pounds. Furthermore, being entirely symmetrical in construction, the pulley, as made, is in perfect running balance without the necessity of adding counter-balance weights.

In designing the ideal wheel to be used under the ideal conditions, the engineer would find three strains to be resisted. In the case of a 24-inch pulley with a 6-inch face, there would probably be in running conditions 450 pounds on the tight side and 150 pounds on the slack side of the belt. This would give a force of 600 pounds, tending to crush the rim and compress the arms. The rim overhang-

ing on each side of the arms, the action of the belt would be to cause buckling of the edges. Then the difference between the tension on the tight and slack sides of the belt, which is equal to 300 pounds, is the effective work of the belt and gives a bending strain to the arms. These calculated strains are all trifling, but frequently, by accident or by quick variations in speed of driving or driven pulley, there are strains ten times as great as those exerted by the belt.

In designing a structure subject to so great variations of stress, the engineer would choose a material which combines strength and toughness, rather than the brittle cast iron.

The weakness of cast iron, when used as the material of pulleys, has been accentuated by casting the rim, arms and hub in one piece. The uniting in one casting of heavy and light sections, and of such as lie at right angles to one another, is as great a mistake, in the moulder's art as were the Siamese twins in the living world.

Instead of pulling together, these three parts pull against one another, and often resist even to open rupture.

The foundryman guards against this happening in his hands by making the casting much too heavy.

The cast-iron pulley to-day has reached its full development. It is true and graceful, is given tolerable balance by adding weights to the light side, and is made to fit exactly one standard size of shaft; but in spite of all these good qualities, worked out by the best engineering skill, it is defective because of the prime mistake in the first operation of making them. The wood pulley, being light, interchangeable as to bore, and cheap, has been sold largely of late years. It is not durable, however, and increases the fire risk where it is carried in stock by dealers. It has been left to Yankee genius and Philadelphia capital to produce a pulley which, being made of the very best and strongest material, corrects the mistake in the standard wheel.

Gears, cranks and levers are each used on many machines, but pulleys are used more than any other mechanical device. There is no factory that does not use them in

quantities. In the present state of the mechanical world they are as universal as machinery itself. Now, a mechanical method which, on a device in such general use, at once reduces the amount of material used to one-third the former practice, reducing also to the same extent the weight and corresponding inertia and frictional resistance to shafting rotation, should be worthy of the attention of the mechanical world. This is accomplished without any expensive operations, and by methods essentially American in their origin, and by which Americans have made not only such simple articles as hardware fixtures, but also such refined ones as watches.

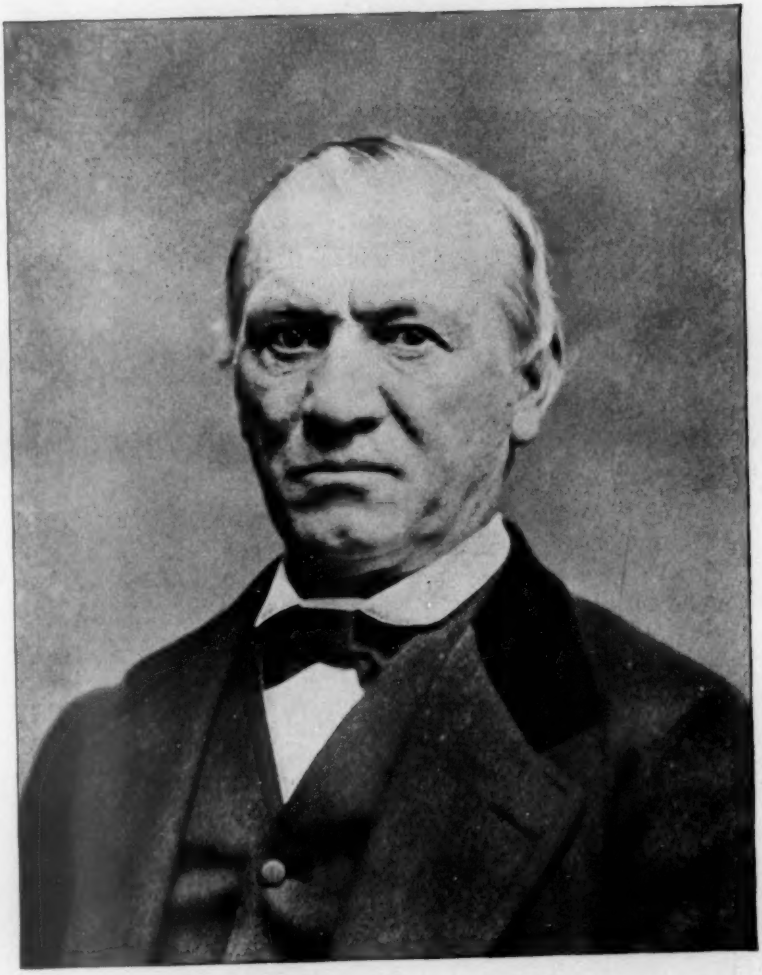
The pulley here described is the invention of Mr. Thomas Corscaden, who has long been engaged in making specialties in steel, some of which are familiar articles to the public to-day. He conceived the idea of making this pulley as far back as 1888. Dull times giving leisure and stimulus to take up something new, drawings and models were made and experimented with. In 1892 patents were taken out on the pulley and on the machinery for making it. With the co-operation of Mr. George V. Cresson, a member of this Institute, and an extensive manufacturer of power-transmitting machinery, the American Pulley Company was formed, and a factory was equipped in Philadelphia for the purpose of manufacturing the pulley under Mr. Corscaden's patents. Under his superintendence special machinery, dies and tools were designed and built, which permit of the production of several hundred pulleys daily.

The pulley has attracted the attention of the engineering public, both at home and abroad, and its extensive adoption already appears to be well assured.

IN MEMORIAM.

ROBERT WRIGHT.

Robert Wright, son of Jonathan and Mary Wright, was born February 19, 1817, at Keighley, Yorkshire, England, and died January 11, 1897, after having lived a life of great usefulness, characterized by a modesty as conspicuous as



ROBERT WRIGHT. (1817–1897.)

were the great events in which he had been one of the chief actors.

His parents emigrated to Philadelphia in 1820, and at an early age he was apprenticed as a mechanic to a firm of Englishmen, named Hyde & Flint, whose place of business was on Beach Street. He subsequently entered the employ of Garrett & Eastwick, who at that time were located in Wagner's Alley, near Seventh and Race Streets. The training he here received and his natural gifts, coupled with the fact that the development of the railway systems of America was in process of evolution, gave him the opportunity, as a mechanic, to prove his worth. His employers, Garrett & Eastwick, were in the front rank as constructors of railway equipment, and it was not strange, therefore, that when Messrs. Harrison, Eastwick & Winans obtained the contract from the Russian Government for the construction and equipment of the line of railway from St. Petersburg to Moscow, they turned to Robert Wright as the mechanic best suited to assume charge of their enterprise.

Accordingly, in 1844 he went to Russia, under a contract with his new employers, and at a salary which, even in these days, would be considered an extremely satisfactory compensation, and which in the days of fifty odd years ago, must have seemed princely to the then young mechanic.

In all the manifold departments of construction and equipment he was prominent, and, enduring the hardships incident to the Russian climate, he kept persistently at his work until the latter part of 1850, when he returned for a short visit to Philadelphia. Returning to Russia in 1851, under a new contract and at an increased compensation, he assumed charge of the Alexandroffsky Head Mechanical Works, near St. Petersburg, and, during the Crimean War, constructed the marine engines for the Russian gun-boat fleet. His achievements in the field of marine engine construction were crowned with as much success as he had already acquired in that of railway equipment.

For his eminent services at this time, the Order of St. Stanislaus was duly conferred upon him by the Czar; and the official notification of the conferment of this honor was

conveyed to him in a letter, a translation of which is herewith given:

"To ROBERT WRIGHT, Chief Mechanic at the Alexandroffsky Head Mechanical Works, near St. Petersburg, Russia:—In consequence of the intermediation of the Ministry of Marine, His Imperial Majesty, by the decision of a Committee of Ministers, has deigned most graciously to grant you, for your exertions in the construction of screw engines for the gun-boat fleet, a silver medal to be worn on the neck, on a ribbon of the Order of St. Stanislaus. The Chancery of the Ministry of Marine informing you of His Majesty's desire, forward the medal herewith.

January 3, 1857. (Signed) COUNT TOLSTOY."

Prior to this mark of imperial distinction, he had become prominent by rescuing a large vessel (for a ship-building company in Perm, Russia), which, owing to some imperfection of construction, had sunk, and having raised the vessel and rebuilt her engines and boilers, he was duly honored by the presentation of a gold cup, suitably inscribed, as a mark of the esteem which his great mechanical skill and ingenuity had gained for him.

Returning to Philadelphia in 1856, and having acquired a competency as a result of his labors, he retired from active mechanical work.

He married, in 1840, Emily Shoch, daughter of George P. and Maria Shoch, and had two children, a daughter, who died in Russia, and a son, who fell a victim in the Civil War, at Murfreesboro, Tenn.

Although taking a lively interest in all the questions of the day, a defect in his hearing, which ultimately approached total deafness, precluded the possibility of his engaging in active work.

He was a great believer in the ability of canals to compete advantageously with our railway systems, and deplored the policy which has resulted in the acquisition by the railroads, through lease or purchase, of the principal canals of the United States, and in the diversion of traffic therefrom, and the falling into decay of those magnificent monuments to the engineering talent and ability of seventy years ago.

He was an earnest vegetarian, a God-fearing and deeply

religious man, who had pronounced convictions of his own, but who was ever tolerant of the opinions of others; and thus for forty years this modest, worthy man lived quietly in our midst, his life saddened by the loss of his children, but brightened by schemes he was contemplating for the ultimate good of his fellow-men.

He had been greatly aided, as a struggling young mechanic, by two of our philanthropic institutions, the FRANKLIN INSTITUTE and the Apprentices' Library. He was a friend of dumb animals, and an admirer of the good work done by the Pennsylvania Society for the Prevention of Cruelty to Animals; and it is to these three worthy institutions that his estate will eventually come, absolutely unhampered by any conditions.

And now, since his modesty was such that he gave no thought to the perpetuation of his name in connection with his munificent gifts, it is right and fitting that we should here place on record the sterling virtues and worth of this honest mechanic, who so lived and died that hundreds, nay, thousands, all unconscious of the donor, may derive great benefits as the result of his industry and thrift.

FREDERICK FRALEY HALLOWELL.

AN EFFICIENCY SURFACE FOR PELTON MOTOR.*

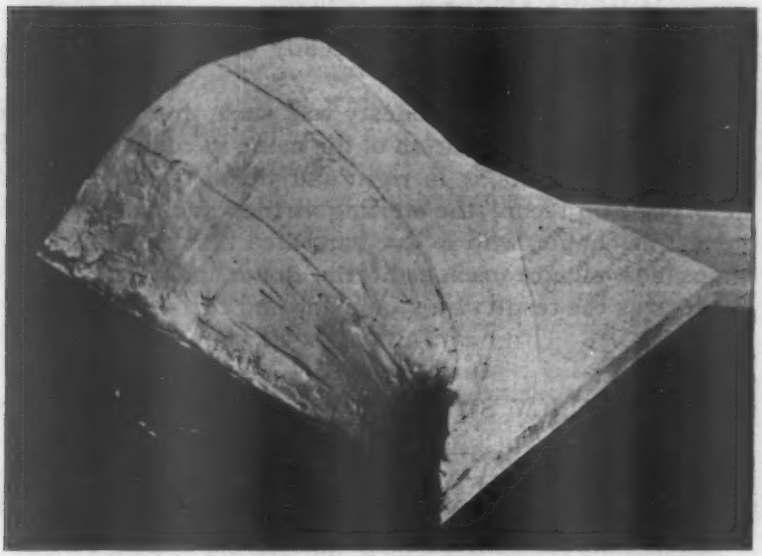
BY W. KENDRICK HATT,
Associate Professor Applied Mechanics, Purdue University, Lafayette, Ind.

When a jet impinges against a series of moving cup-shaped vanes, as in the Pelton motor, the entire kinetic energy of the jet may, theoretically, be given up to the motor, provided the angle of total deviation (relatively to the vane) of the jet leaving the vane be 180° from its original direction, and provided the vanes move with a velocity equal to half the velocity of the particles of the jet. For any other velocity of the vane (the speed of the jet remaining constant), the efficiency of the motor is reduced;

*Paper presented to Indiana Academy of Sciences, December 27, 1896.

so that the efficiency of the motor for a given head of water will vary from zero value at zero vane speed to its maximum value of unity for a vane speed equal to one-half the speed of the jet, and will reduce to zero again for a speed equal to the speed of the jet. In any actual Pelton wheel, the friction in cups, lateral escape of water, interference of cups with each other's supply, etc., combine to reduce the efficiency.

Now, if the three variables—speed of cup, head of water, and efficiency—be represented respectively on the three axes,



X, *Y*, *Z*, an efficiency surface will result. Such a surface will have its zero efficiency contours, one coincident with the *Y* axis and the other a parabola tangent to the *X* axis at the origin. There will be a ridge of unit efficiency extending from a point of height equal to unity at the zero of co-ordinates, in the curve of a parabola, whose projection on the *X Y* plane lies midway between the two zero contours. The section parallel to the *Z X* plane will be a parabola convex upwards. The equation of the surface may be obtained thus: The power exerted on a series of vanes, moving with

velocity $= v$, by a jet whose particles move with a velocity $= c$, is (Church's Mechanics):

$$(1) \qquad L = \frac{Q\,m}{g}\,[1 - \cos a]\,(c - v)\,v$$

where Q is the quantity of water used, and the g the acceleration of gravity, and m is the heaviness of the water. For Pelton motor $\cos a = -1$; therefore,

$$(2) \qquad L = \frac{Q\,m}{g}\,2\,(c - v)\,v$$

and the efficiency,

$$(3) \qquad = \frac{Q\,m}{g}\,\frac{2\,(c - v)\,v}{Q\,m\,h}$$

where h is the head back of jet; hence efficiency

$$= \frac{2}{g}\left\{ \pm \frac{\sqrt{2\,g\,h}}{h}\,v - \frac{v^2}{h} \right\} \text{ or}$$

$$(4) \qquad z = \frac{2}{g}\left\{ \pm \sqrt{\frac{2\,g}{y}}\,x - \frac{x^2}{y} \right\}$$

When y is a constant and $= h^1$

$$(5) \qquad z = \frac{2}{g}\left\{ \pm \sqrt{\frac{2\,g}{h^1}}\,x - \frac{x^2}{h^1} \right\}$$

So that a cross-section of the surface parallel to XZ plane is a parabola convex upward. The limiting cases are for $h^1 = o$, when the parabola becomes the Z axis; and for $h^1 = \infty$, when it is a straight line at infinity parallel to X axis. When

$$x = \frac{\sqrt{2\,g\,h}}{2},\ z = 1.$$

Again, when x is constant and $= S$

$$(6) \qquad z = \frac{2}{g}\left[\sqrt{\frac{2\,g}{y}}\,S - \frac{S^2}{y}\right]$$

or

(7) $$z^2 + \frac{4\,S^2}{y\,g}\left(z-2\right) + \frac{4\,S^4}{g^2}\,\frac{1}{y^2} = o$$

$$\frac{d\,z}{d\,y} = \frac{2}{g}\left[+\frac{S^2}{y^2} - \frac{\sqrt{2\,g}\,S}{2\,y^{\frac{3}{2}}}\right]$$

Put

$$\frac{d\,z}{d\,y} = o$$

then

$$y_m = \frac{2\,S^2}{g}$$

for maximum efficiency.

Substituting this value of y_m in (6), $z = 1$.

If $$y = o,\ \frac{d\,z}{d\,y} = \infty$$

therefore, at the origin the tangent to the curve is vertical. If

$$y = \infty,\ \frac{d\,z}{d\,y} = o$$

therefore, at infinity the curve becomes horizontal. If $z = o, y = \infty$, or else

$$y = \frac{S^2}{2\,g}$$

Thus the section parallel to the $Z\ Y$ plane is a curve whose zero value occurs at

$$y = \frac{S^2}{2\,g}$$

whose maximum value occurs at

$$y = \frac{4\,S^2}{2\,g}$$

and whose zero value again occurs at infinity.

The equation to the curve is of form

$$z + \frac{C}{y}\,(z-2) + \frac{C^1}{y^2} = o$$

and a point of inflection occurs for a value of

$$y = \frac{32\,S^2}{9\,g}$$

If z be made constant,

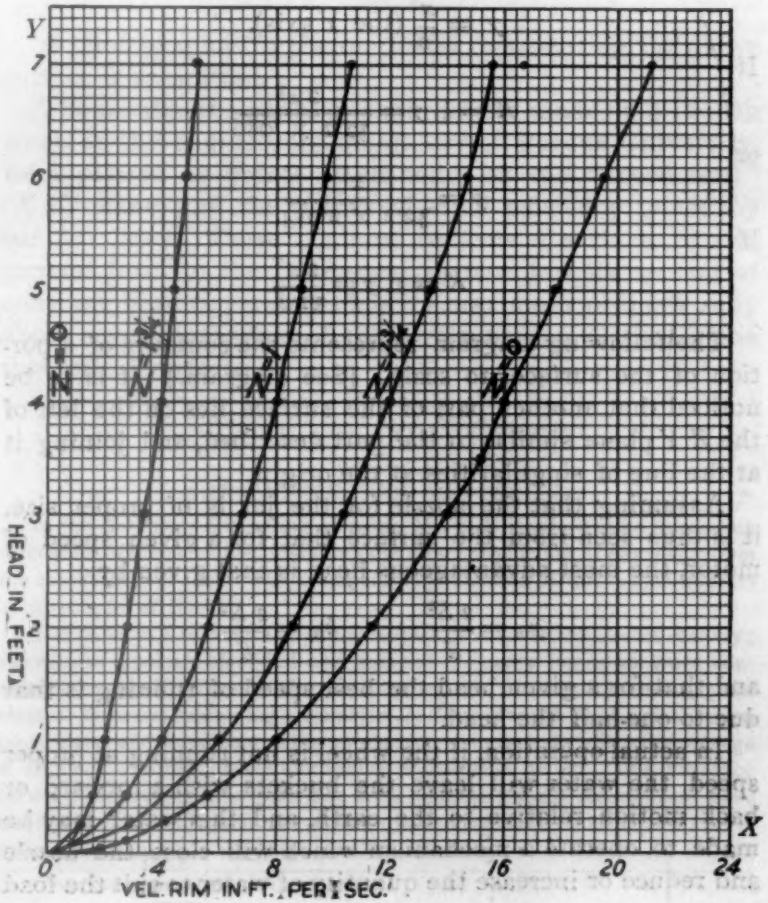
$$z = K = \frac{2}{g}\left(x\sqrt{\frac{2\,g}{y}} - \frac{x^2}{y}\right)$$

or,

$$\frac{g^2}{4}K^2 + g\,(K-2)\,\frac{x^2}{y} + \frac{x^4}{y^2} = 0$$

or,

$$y = \frac{2\,x^2}{g\,(2 - K \pm 2\sqrt{1-K})}$$



Giving different values to K, we determine the horizontal contours of the efficiency surface. They will be parabolæ, two in each horizontal plane on the right-hand side of the $Z\ Y$ plane, tangent to each other and to the X axis at the origin and extending in the same direction; because for $o < K \leq 1$

$$2 - K \pm 2\sqrt{1 - K} > o$$

If

$$K = o, y = \frac{x^2}{2 \times 32{\cdot}2}$$

and

$$y = \frac{x^2}{o} \text{ (the } Y \text{ axis).}$$

If

$$K = \tfrac{1}{2}, y = \frac{2x^2}{32{\cdot}2 \times {\cdot}086}$$

or

$$y = \frac{x^2}{32{\cdot}2 \times 2{\cdot}914}$$

If

$$K = 1, y = \frac{2x^2}{32{\cdot}2}$$

The following diagram represents the contours of a portion of the surface, to scale. [See diagram.] It is to be noticed that another part of the surface lies on the left of the $Z\ Y$ plane similar to the part described, and joining it at the line of singularities at the origin.

Assuming that the nozzle for the jet is of proper size, it is thus seen from the surface that for a given speed of motor, the most advantageous head is that given by

$$y_m = \frac{2S^2}{g} \qquad h_n = \frac{2S^2}{g}$$

and that for a given head the best speed of running is that due to one-half the head.

In actual operation, if the wheel is not running at proper speed, the water will leave the buckets with a forward or back motion relative to the earth, and this water may be made to operate a mechanism which will close the nozzle and reduce or increase the quantity of water to suit the load

on the wheel. Or, again, the wheel may operate a governor, which will open or close a valve in the supply pipe, and so increase or decrease head controlling the jet.

From the formula

$$h = \frac{2\,S^2}{g}$$

it would seem that the theoretically best head for a given speed, with proper nozzle, to which the throttle should work would be

$$\frac{S^2}{16{\cdot}1}$$

A photograph of a plaster model representing the above surface is submitted.

The results of a series of experiments, made on a 12-inch wheel in the engineering laboratory of Purdue University, were platted as points of efficiency on the "speed-head" (X Y) plane, and the points of equal efficiency joined by contour lines. These contours indicate a surface, like in general form to the theoretical surface, but its section of constant head (a parabola) has its maximum ordinate only about seven-tenths that of the corresponding section of the theoretical surface.

NOTES AND COMMENTS.*

THERMO-ELECTRIC BATTERIES.

In the *American Electrician* of April, Mr. C. J. Reed gives an interesting discussion of the principles involving the direct production of electricity from the combustion of fuel. The accompanying abstract of this paper appears in the *Electrical World:*

The paper is a summary of the principles of the thermo-electric battery; the various types are classified and some of the more important ones considered in detail. Thermo-electric batteries are divided into two general classes: those not containing electrolytes, or those in which no chemical action takes place, and those containing an electrolyte, or those in which the passage of an electric current causes electrolysis or chemical action. The difference between these types is so great that those belonging to the second class have frequently been mistaken for galvanic batteries; this latter type is said to have comparatively a very high possible efficiency, both on account of high

* From the Secretary's monthly reports.

thermo-electric power, and of the fact that the chemical or electrolytic reactions may be used to advantage to oxidize fuel within the thermo-electric circuit, its energy being added to the circuit. The Archereau and Jacques cell belongs to the second class; while great claims have been made for the efficiency of this cell, its commercial utility will depend more upon the labor and cost of renewing the electrolyte, carbon and iron pots, and of the convenience and adaptability, than upon its efficiency. Of the Case cell, it is stated that the energy concerned in the chemical reactions takes no part whatever in the production of the electric energy; any chemical reaction which evolves energy must, on reversing, absorb the same amount of energy, and any chemical reaction which absorbs energy must, on reversing, evolve the same amount of energy; the supposition that the chemical action in this cell contributes in any way to the production of the electrical energy involves the admission that an isolatad body of matter is capable of absorbing external heat at a low temperature and evolving it without loss at a higher temperature, which is impossible, since it implies the possibility of perpetual motion. The conclusion arrived at is that a study of the thermo-electric properties of bodies heretofore examined gives little or no reason to hope that this method will ever be preferred for the transformation of energy on a large scale, except through the discovery of new chemical elements having properties radically different from the properties of any known substance; while there is undoubtedly a possibility of such a discovery, the probability is not encouraging.

ACETYLENE GAS IN PHILADELPHIA.

The Philadelphia Fire Underwriters' Association has decided to grant permission for the use of acetylene gas in liquefied form under pressure for lighting purposes, provided that the pressure of gas on the piping in the building to be assured shall at no time exceed one-quarter pound per square inch, and that the cylinder containing the liquefied gas under pressure and all pressure-reducing and safety devices be located outside of such building, and in a separate building well ventilated to the outer air, but of sufficient strength to protect the apparatus from outside interference and from the weather (especially the sun's rays); and that the supply pipe for the building be provided with a hand valve just inside of the building assured, so that the gas may be entirely shut off from such building. It is also provided that the cylinder containing the liquefied gas under pressure shall be equipped with a safety valve to protect against both excessive pressure and unusual increase of temperature, and that both the pressure-reducing and the safety (mercury) valves shall be provided with vent pipes opening into the outer air; and that no acetylene gas or calcium carbide shall be stored on the premises.

THE MINERAL PRODUCTION OF GERMANY IN 1896.

The *Engineering and Mining Journal* publishes the following summary of the more important items of the mineral product of Germany for 1896, as compared with the previous year, viz.:

		1895.	1896.	Changes.		Per cent.
Coal	Metric Tons.	79,169,276	85,639,861	Inc.	6,470,585	8·2
Brown Coal (lignite)	"	24,788,363	26,797,880	Inc.	2,009,517	8·1
Petroleum	"	17,051	20,395	Inc.	3,344	19·6
Rock Salt	"	686,940	755,833	Inc.	68,893	10·0
Kainit	"	680,174	856,290	Inc.	176,116	25·8
Other potash salts	"	841,748	924,140	Inc.	82,392	9·8
Iron ores	"	12,349,600	14,162,315	Inc.	1,812,715	14·7
Zinc ores	"	706,423	729,872	Inc.	23,449	33·1
Lead ores	"	161,614	154,660	Dec.	6,954	38·7
Copper ores	"	633,354	717,306	Inc.	83,952	13·3
Gold and silver ores	"	10,845	18,487	Inc.	8,358	77·4
Cobalt, nickel and bismuth ores	"	5,180	4,087	Dec.	1,093	21·0
Iron pyrites	"	127,036	124,950	Dec.	2,086	1·6

The year was evidently one of great activity, all the important products showing increases of considerable importance. The most valuable of the potash salts reported in 1896 were 174,515 tons of chlorate of potash and 71,958 tons of Glauber salts. The principal iron-ore-producing districts last year were Elsass-Lothringen, 4,841,633 tons; Luxemburg, 4,758,741 tons; Bonn, 2,680,889 tons; Breslau (Silesia), 529,602 tons.

Franklin Institute.

[*Proceedings of the stated meeting, held Wednesday, May 19, 1897.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 19, 1897.

MR. JOHN BIRKINBINE, President, in the chair.

Present, 110 members and visitors.

Additions to membership since last report, 24.

Mr. Charles James was elected to the Committee on Science and the Arts, to fill the unexpired term of Prof. Arthur Beardsley, resigned.

The Secretary, by instruction from the same committee, reported an abstract from the committee's record in the case of Thomas Shaw's gunpowder tester, referred for investigation by the Institute at its stated meeting of June 21, 1893.

Consideration of the report was deferred until the stated meeting of June.

Lieut. Geo. A. Squier, U.S.A., presented a communication on "The Synchronograph, a New Method of Rapidly Transmitting Intelligence." This system is the joint invention of Lieutenant Squier and Prof. A. C. Crehore, Dartmouth College, Hanover, N. H., and involves a novel and ingenious application of the alternating current. By this system, the speed of telegraphic transmission is said to be enormously increased over that of all methods hitherto devised.

The meeting then proceeded to the continuation of the discussion of "The Smoke Nuisance and its Regulation," deferred from the stated meeting of April 21st.

The following gentlemen participated in the debate, viz.: Mr. H. H. Suplee, Mr. Geo. S. Strong (New York), Mr. J. H. Sternbergh (Reading, Pa.), Dr. Coleman Sellers, Mr. Wm. A. Ingham, Mr. Washington Jones, Mr. Wm. Trautwine, Mr. Arthur Falkenau, Mr. P. A. B. Winand, Prof. H. W. Spangler and Dr. Wm. H. Ford.

Mr. A. E. Outerbridge, Jr., closed the discussion, and offered the following preamble and resolutions:

WHEREAS, The Board of Health of the City of Philadelphia has requested the Franklin Institute to investigate the question of smoke prevention and to offer practical suggestions relative thereto; and

WHEREAS, The use of bituminous coal for fuel is increasing in this city, and is likely so to continue in the future; and

WHEREAS, It appears from testimony of scientists and expert mechanics, presented at this meeting, by invitation of this Institute, that it is practicable to burn bituminous coal in stationary boilers and furnaces without creating a smoke nuisance; therefore, be it

Resolved, That it is the sense of this meeting that the continuous or frequent discharge of dense black smoke from the combustion of bituminous coal is unnecessary, and should not be permitted within the city limits.

Resolved, That a copy of these resolutions be sent to the Mayor, to the President of the Board of Health, and to the Presidents of City Councils.

These were discussed by Messrs. H. F. Colvin, Spencer Fullerton, Samuel M. Vauclain, William R. Fisher and Max Livingstone, and, on motion, were referred to the Board of Managers, with the request to report thereon at the next stated meeting of the Institute.

Adjourned.

WM. H. WAHL, *Secretary.*

COMMITTEE ON SCIENCE AND THE ARTS.

[*Abstract of proceedings of the stated meeting held May 5, 1897.*]

MR. JAMES CHRISTIE in the chair.

REPORTS on the following subjects passed first reading:

Williams' Typewriting Machine, Williams Typewriter Co., New York.

Rotary Steam Engine, Samuel T. Lewis, Philadelphia, Pa.

Gear-Moulding Machine, Samuel Groves, Pittsburgh, Pa.

Automatic Fluid-Pressure Friction Clutch, George M. Richards, Erie, Pa.

Automatic Safety Device for Electric Circuits, Lewis G. Rowand, Camden, N. J.

Window Ventilator, Percy A. Sanguinetti.

Screens for Photo-Mechanical Engraring, Louis E. and Max Levy.

Metallic Corner Bead, Edward B. Marsh, Lexington, Mass.

Proposition for the Trisection of the Angle, Chas. Morrell, Chicago, Ills.

Flying Machine, Praull Aëromotor Co., Phila.

Investigations in the Molecular Physics of Cast Iron, A. E. Outerbridge, Jr.

REPORTS on the following subjects were adopted:

Knife-Sharpening Attachment for Sewing Machines, Mary H. P. Cox, Kirkham, Md.

U. S. Letters-Patent No. 577,127, February 16, 1897.

ABSTRACT.—The device is a clamp adapted to be attached to the table of a sewing machine, supporting an extensible post upon which is a bearing carrying a shaft. On one end of this shaft is a friction pulley, intended to engage with the fly-wheel of the machine, and on the other end an emery wheel. When the attachment is in position on a sewing machine, and the fly-wheel is started by the treadle, the emery wheel will grind anything applied to it.

The report finds that the invention has been substantially anticipated. [*Sub-Committee.*—G. Morgan Eldridge, Spencer Fullerton and John Haug.]

Battery Motor.—A. A. Kent, Worcester, Mass.

ABSTRACT.—This invention is a series-wound motor, the field winding of which is so arranged that an increased number of turns of wire can be added when the machine is used as a dynamo, so as to increase the strength of the field. The armature, which is the part of the machine which it is claimed has special features, is made of cast iron, with projecting poles. The number of these poles, it is claimed, reduces the friction of the bearings.

The report finds that this feature is shown, and in a more marked degree than in this particular design, in the Gramme ring, Siemens drum, or Pacinotti type of armature; that the motor embodies no special features that are new in the art; and that motors of higher efficiency have been built and are on the market. [*Sub-Committee.*—C. J. Reed, Thos. Spencer, Wm. C. L. Eglin, W. Sonneberg.]

Rotary Steam Engine.—Samuel T. Lewis, Philadelphia, Pa.

ABSTRACT.—A central disk is furnished with slots, in which move slides or pistons having projections. It has also a hub, through which is an opening for a shaft. It is surrounded by a casing containing steam ports and an exhaust port. On top of the casing is a steam chest having a slide valve for steam admission to the several steam ports, and for reversing the engine. On each side of the disk is a casing in two sections, which form a circular space with separate pistons in them. Steam ways or ports are in the outside casing and connect with the separate divisions on each side. The pistons travel with the disk in its movement, and the object of the several steam ways is to use steam expansively, by allowing it to flow out by one or more of them at one time.

The report finds that while much ingenuity is displayed in the machine, it is very complicated, and would be so wasteful in the use of steam as to be practically valueless. [*Sub-Committee.*—H. F. Colvin, J. M. Emanuel, Spencer Fullerton.]

Automatic Disinfectant Ejector.—Wm. B. Hollingshead, Bronxville N. Y.

ABSTRACT.—This device consists of a receptacle for a disinfecting liquid of any kind intended to be placed in communication with the flush pipe of a sink, etc., and the construction is such that every time the flush is operated a small quantity of the disinfecting liquid is caused, automatically, to be ejected from the reservoir and to mingle with the flush-water as it passes to the sink. For the mechanism of the device reference is made to U. S. Letters-Patent No. 510,389, December 5, 1893.

The report finds that the device cannot be depended upon to remain in serviceable condition for any length of time, because of the liability of obstruction and the difficulty of detecting the stoppage and of cleaning the tube when the obstruction is discovered. [*Sub-Committee.*—Henry R. Heyl, John G. Bullock.]

FOLLOWING is a list of applications received for investigation by the Committee, since April 22, 1897:

No. 1971. Crehore and Squier's Synchronograph. Application filed May 8.
" 1972. Willard & Frick's Time Recorder. Application filed May 20.
" 1973. Arndt's Econometer. Application filed May 21. W.

SECTIONS.

CHEIMCAL SECTION.—Stated meeting, Tuesday, May 18th, Dr. Joseph W. Richards in the chair.

Mr. Waldron Shapleigh, Chemist to the Welsbach Company, presented some "Notes on Lucium." (To be published.)

Messrs. C. T. Mixer and H. W. Dubois presented some "Notes on the Determination of Insoluble Phosphorus in Iron Ores." (To be published.)

Dr. Harry F. Keller, for himself and Philip Maas, described "Some New Derivatives of Diacetyl." (To be published.)

ELECTRICAL SECTION.—The card of the stated meeting of Tuesday, May 25, contains the following items:

"Electric Elevators," by Mr. Joseph Sachs, New York. "Exhibition of, and Discussion upon, Rheostats." Discussion to be opened by Mr. C. E. Carpenter, Ward Leonard Electrical Company, New York.

MINING AND METALLURGICAL SECTION.—Stated meeting, Wednesday, May 12th, Mr Benj. Smith Lyman in the chair.

The Section adopted a set of rules for its government.

The following permanent officers were elected: President, Benj. Smith Lyman; Vice-Presidents, Dr. D. K. Tuttle, A. E. Outerbridge, Jr.; Secretary, Wm. C. Henderson; Conservator, Dr. Wm. H. Wahl; Committee on Finance, Messrs. Henry G. Morris, Joseph Richards; Committee on Papers, Messrs. F. L. Garrison, Charles James and C. J. Reed.

Professor Garrison read a paper on "Underground Water Supply," which evoked considerable discussion. (To be published.) W.

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THE JOURNAL OF THE FRANKLIN INSTITUTE

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Science and the Mechanic Arts.

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with the Assistance of

DR. WM. H. WAHL, Secretary of the Institute.

JUNE, 1897. No. 6.

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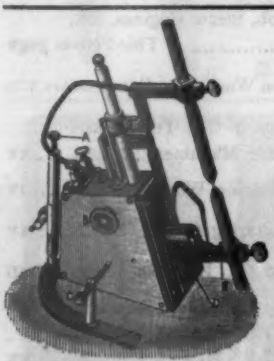

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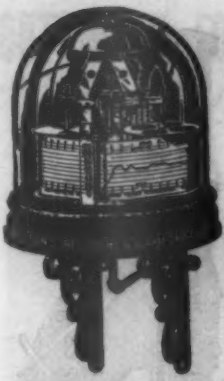

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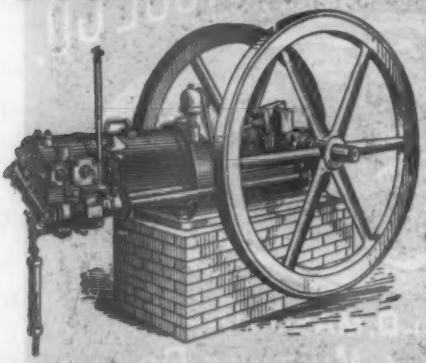

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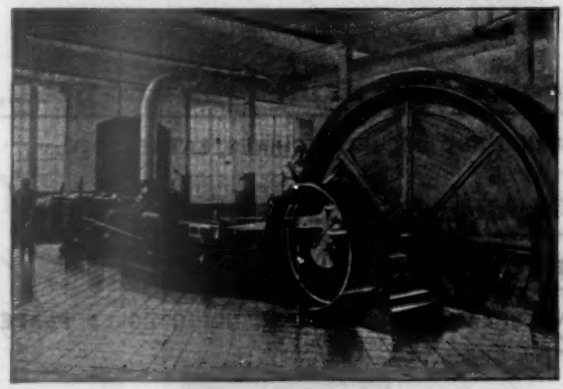

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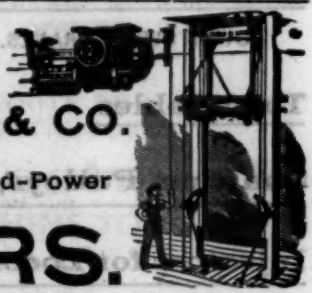

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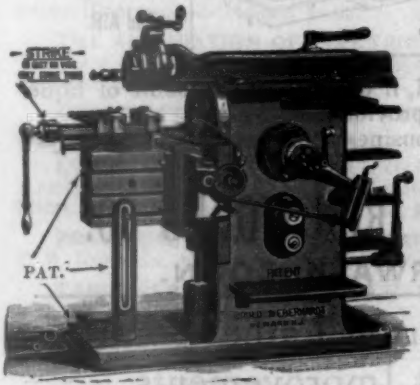

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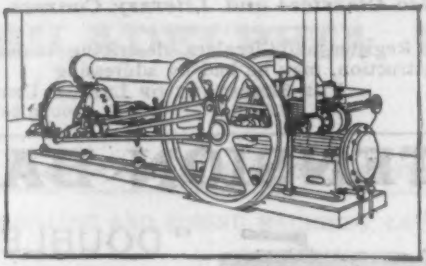

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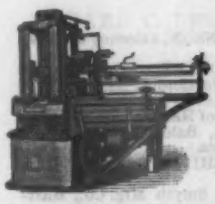

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